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ABSTRACT

This course is intended to give students a comprehensive experience in current and future manufacturing materials and processes. It familiarizes students with: (1) base of composite materials; (2) composites--a very light, strong material used in spacecraft and stealth aircraft; (3) laminates; (4) advanced materials--especially aluminum alloys; (5) computer-assisted design (CAD) and computer-assisted design and manufacturing (CAD/CAM); and (6) traditional manufacturing processes peculiar to the processing of composites. The document begins with a brief report of the curriculum development project. There are 10 units in this course: (1) introduction to advanced materials used in manufacturing and fabrication; (2) characteristics of composite materials; (3) design considerations--processing composite materials; (4) design and drafting--CAD utilization; (5) safety; (6) machine processes; (7) integrated CAD/CAM with advanced materials machining and fabricating processes; (8) fabrication processes; (9) finishing operations; and (10) other technical occupations in the composite materials industry. For each unit, the following are provided: competencies, performance objectives, learning activities, teaching aids, and a list of evaluation methods. In addition, there are instructor's notes for teaching CAD with CADKEY software, a pilot project--corrosion-proof boat trailer, research, proposed articulation agreements, and 12 references. (NLA)

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DEVELOPMENT OF SPECIALIZED ADVANCED MATERIALS CURRICULUM
(CONTRACT NUMBER: 85-8034) /

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EVERETT, PENNSYLVANIA

JUNE 30, 1988

PENNSYLVANIA DEPARTMENT OF EDUCATION
BUREAU OF VOCATIONAL AND ADULT EDUCATION
CURRICULUM AND PERSONNEL DEVELOPMENT SECTION

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PREFACE

This course is intended to give each student a comprehensive experience in current and future manufacturing materials and processes. It familiarizes students with - the base of composite materials; composites, a very light, strong materials used in spacecraft and stealth aircraft; laminates; advanced materials, expecially aluminum alloys; CAD, CAD/CAM, and CAMM - modern design, drafting and manufacturing tools; as well as traditional manufacturing processes peculiar to the processing of composites. It (the course) addresses some of the criticial needs fo employers and it is hoped that this course will give its students an edge in employability. In short, this teaching guide is an attempt to bring vocational students and teachers into some of the latest technology used in manufacturing.

Now for some acknowledgements. First, much thanks is due to local composite manufacturers. Creative Pultrusions and Bedford Reinforced Plastics both gave the authors tours of their plants and answered extensive questions regarding the manufacturing of fiberglass-reinforced plastics. David Evans, Technical Director of Creative Pultrusions, was particularly helpful and authorized us to use material from Creative Pultrusions Design Guide.

Second, Dr. Terry Richardson, author of Industrial Plastics: Theory and Application has given his permission to use material for the book. It is a major reference and the suggested text. He has also written another book which might be more helpful than this one. It is named Composites: A Design Guide.

Third, Mr. Barry Dallara, Director of the Bedford-Everett Area Vocational-Technical School, guided the project.

Fourth, Mr. Tom Malgren, Engineering Professor at the University of Pittsburgh at Johnstown did most of the preliminary work and research for the project. He was also responsible for the CAD and CAD/CAM curriculum and the engineering for the corrosion-free boat project.

Lastly, we all consulted each other for our respective areas of strength. The other members of the project team were Mr. Steve Orner and Mr. Paul Leister.

SECTION II - FINAL REPORT SUMMARY

II. Final Report Summary

A. Abstract

1. Agency: Bedford-Everett AVTS

   Adress: RD # 1 Box 460, Everett, PA 15537

   Project Title: Development of Specialized Advanced Materials Curriculum

2. Statement of Purpose: To develop a CBVE curriculum in advanced materials and the advanced processes needed to be competitive in a world market with composite materials and others that are displacing steel and other traditional manufacturing materials.

3. Objectives Planned:

   a. To update and include an advanced material technology program in the vocational education curriculum to respond to local industry needs and provide that at least 75% of successful completers are placed in jobs for which they are trained.

   b. To provide both entry-level and upgrade placement of successful advanced materials program completers in jobs for which they are trained, (minimum of 75% in both categories).

c. To implement a CBVE Program in advanced materials technology that insures that 90% of those enrolled will complete the program.

d. To provide a curriculum for advanced technology training in adult post-secondary vocational education programs by September 1, 1988.

4. Objectives Achieved:

Objective number one has been achieved completely to date. A CBVE composites curriculum has been integrated into the schools curriculum and placement will be reviewed at the end of the 1988-89 school year.

Objective 2,3, & 4 will be evaluated at the end of the 1988-89 school year.

B. Finacial Summary

Instructional Salary	2,705.00	2,630.50
Instructional Benefits	442.00	407.21
Contracted Services	26,189.00	26,189.00
Other Expenditures	9,515.00	9,157.23
TOTALS	$ 38,851.00	$ 38,383.94

SECTION III - PROJECT APPROACH/METHODOLOGY

III. Project Approach/Methodology

The project was executed by three individuals. A member of the University of Pittsburgh at Johnstown engineering faculty, Mr. Thomas Malmgren, Mr. Stephen Orner, a member of Bedford-Everett AVTS faculty, and Mr. Paul Leister, a Technology Education instructor. Mr. Malmgren and Mr. Orner developed the curriculum outline and content after completing as exhaustive survey of all manufacturing industries within a 50 mile radius of the school and what types of materials were being used by such industies.

Upon completion of the survey, it becomes obvious that composites were the most appropriate advanced material to incorporate into the Bedford-Everett AVTS curriculum. Several plant visits were conducted by Mr. Orner and Mr. Malmgren in September and October 1987 to become familiar with the products and manufacturing processes of several of the local companies which make composite products. (Gilmour Manufacturing Co., Green Garden Inc., Bedford Reinforced Plastics, and Creative Pultrusions.)

Both Gilmour and Green Garden produce thermoplastic and zinc die cast parts, primarily for lawn and garden products. (i.e. garden hose mending parts, spray nozzles, siphons, sprayers, etc.) Almost all of their products are manufactured and assembled on-site. Very few parts used in the assembly of their finished products are purchased from outside sources. Gilmour is a very progressive company with many automated and robotized operations, while Green Garden is manual labor oriented. Both companies have experienced rapid growth over the past 5 years. Employment opportunities for AVTS graduates would be limited since employee turnover is virtually nonexistent, and openings occur only as a result of expansion of the companies.

Bedford Reinforced Plastics and Creative Pultrusions are companies in the local area that produce polymer composite pultrusions used for a variety of applications from structural fabrications to non-conducting electrical parts to corrosion resistant products. During the visit of applications from structural fabrications to non-conducting electrical parts to corrosion resistant products. During the visit to Bedford Reinforced Plastics, they observed workers fabricating and assembling parts for a customer. It was mentioned that many of their customers wanted finished fabrications made from the reinforced fiberglass parts and found it difficult to find companies willing to produce the fabrications. Although they are primarily in the business of producing the raw materials, they have found it necessary to also be in the fabrication business. This is an excellent opportunity for AVTS graduates trained in the area of fabrication and machining of reinforced fiberglass to contract work which could easily be done in a small business or job shop type environment. This need could readily be met by the Advanced Materials and Advanced Metals curriculum.

It was then decided that the use of reinforced fiberglass pultrusions for the purpose of designing, fabricating, and producing finished products was a very real need in the local area and would be an excellent choice as a starting point for the new curriculum. The special safety, tooling, machining, properties/characteristics, joining, and fabricating considerations of using these materials are not being taught anywhere at the AVTS level. Many techniques used by manufacturers are not documented or considered proprietary information. The development of a curriculum in the area should prove to be worthwhile task that should give readily marketable skills to AVTS graduates. Furthermore, the use of current Computer-Aided-Manufacturing (CAM) techniques can be readily used in the preparation of parts for fabrication, which will also enhance the training skills of students in this curriculum.

Resource materials for use in developing a curriculum were located and collected. Those materials became the source for the AVTS instructors to begin writing the curriculum materials.

The proposed curriculum was reviewed and approved by the Bedford-Everett AVTS Joint Operating Committee and the school's General Advisory Council. Other option considered and developed were articulation between the AVTS program and the Engineering Curriculum at the UPJ campus, a cooperative education commitment between the school and the composite industries and future materials, equipment and funding requirements.

DEVELOPLMENT OF SPECIALIZED ADVANCED MATERIALS TECHNOLOGY

CURRICULUM DEVELOPMENT

1987-88

A. RATIONALE

The Bedford-Everett Area Vocational-Technical School proposes to expand the school's vocational-technical education curriculum for secondary programs.

Secondary programs are in need of new technology curriculum to reflect current industrial practices. The school currently offers metal fabrication training and requires this curriculum utilization to expand course offerings available to all students.

The geographic and economic conditions of Bedford County require additional technical training for the workforce. Citizens are in need of additional education to meet the labor demands within commuting distance of this area. The unemployment rate in Bedford County was 8.2% in December of 1986, in excess of twice the national average.

The proposed curriculum needs will improve the district's ability to provide programs that assist local business and industry, and will specifically improve the training of students enrolled in vocational education classes. This instruction will also provide the area with additional training opportunities in occupations projected as rapidly growing. As published in The Pennsylvania Occupational Information System Labor Demand Supply Relationship Component, the need for workers in the careers related to Metal Fabrication/Advanced Materials Technology all reflect employment growth thru 1990. The Pennsylvania Occupational Information Coordinating Committee has indicated that a need for each of these occupational areas exists in Pennsylvania. Numerous local businesses and industries have indicated the need for personnel trained in Metal Technology and Advanced Materials Technology.

The development of Metal Technology and Advanced Materials Technology curriculum will be a cost-effective method of updating our programs; because our instructors will be trained during the time he will be writing the curriculum. Students enrolled in this course will be trained in the various uses and applications of advanced and composite materials to include aluminum, titanium, fiberglass, ceramic fiber, carbon fiber, aramid fiber, glass fiber, and thermalplastic fiber. The Bedford-Everett Area Vocational-Technical School will use this new curriculum in conjunction with other school resources to provide the best possible programs with the most cost-effective procedures. The curriculum will be utilized by metal fabrication students, and it is estimated that 90% of those trained annually will become occupationally competent in its use.

The Bedford-Everett Area Vocational-Technical School cannot support the training proposed without federal funding support. Depressed economic conditions make private sector or client financing impossible. The Bedford-Everett Area Vocational-Technical School is the only agency in the geographic area with sufficient vocational education facilities to provide the proposed training. The Area Vocational-Technical School has made inquiries to both the Bedford County Planning Commission and the local OES Office concerning the availability of CBOs to provide the proposed training. (See attached letter concerning involvement of CBOs in the project.)

B. OBJECTIVES

1. To update and include an advanced material technology program in the vocational education curriculum to respond to local industry needs and provide that at least 75% of successful completers are placed in jobs for which they are trained.
2. To provide both entry-level and upgrade placement of successful advanced material program completers in jobs for which they are trained, (minimum of 75% in both categories).
3. To implement a CBVE Program in advanced materials technology that insures that 90% of those enrolled will complete the program.
4. To provide a curriculum for advanced technology training in adult post-secondary vocational education programs by September 1, 1988.

C. PROCEDURES

The need for vocational education training programs to develop advanced technology curriculum was evaluated by the Area Vocational-Technical School General Vocational Advisory Council, past graduates, and current program participants. The targeted occupations are projected to grow over the next years in the OES

Annual Job Guide 1985. Curriculum beginning in September will reflect the use of the advanced technology equipment. Programs will require new curriculum development to insure the successful integration of this new equipment. *This is a special vocational program.* It differs from regular vocational programs by utilizing new curriculum with advanced technology equipment. This project will greatly expand the school's ability to provide new training programs.

The application will be available for review by the local PIC Council and other interested parties. *The Area Vocational-Technical School accepts the responsibility to maintain accurate records to substantiate each expenditure for which reimbursement is requested.*

D. PERSONNEL

Curriculum developed to support approved PPPDE Vocational Education Programs will be selected by the school's Director of Vocational Education, Mr. Barry L. Dallara, the department heads of each vocational program involved in the project, and the Bedford-Everett Area Vocational-Technical School Advanced Technology Steering Committee.

Instructors involved in the programs will be qualified thru business or industry experience.

E. FACILITIES

Facilities utilized include the metal fabrication area and library in the Bedford-Everett Vocational-Technical School. All facilities will be upgraded with advanced materials technology equipment.

F. SEX EQUITY

The Bedford-Everett Area Vocational-Technical School subscribes to the importance of sex equity and nondiscriminatory policies. The Area Vocational-Technical School guarantees equity in employment of personnel and in instructional opportunity for students. (See attached letter from Chief School Administrator.)

G. EVALUATION

Evaluation will take a multi-faceted approach. The first level of evaluation will be at the student-teacher level. The Area Vocational-Technical School's administrative staff will evaluate the effects of student achievement after the implementation of the advanced materials technology curriculum. The program will be evaluated through student and teacher evaluation instruments, (see attached copy), the placement rate of participants, and long-term follow-up procedures. The job placement coordinator will contact successful completers to provide additional feedback for future program considerations.

H. Computer Search

A computer search has been conducted thru VEIN, the National Center for Vocational Education and L.I.C.E., Penn state internal computer network.

SECTION - IV PROJECT SUMMARY

IV. Project Summary

Purpose - Intent

Research was done to establish a list of over 40 companies in the Bedford and adjoining counties which either manufactured or processed parts utilizing advanced materials replacing metals or advanced metals. Searching through this data base indicated that the majority (over 20) of these companies either make plastic or composite parts or make tooling for manufacturing these parts. Other companies manufactured ceramic, rubber, glass, and powdered metal products. Manufacturing with plastics and composites and the welding and joining of these materials appears to be a good starting point since the Bedford-Everett AVTS already has a fabrication program for metals.

Background

There has been very little work done in the area of composites and the processes used to manufacture related products. Although new companies are producing many products comprised of composites, fabricating products from different pieces of composites and other advanced materials is near nil. The companies in our geographic region are producing standard items used to construct composite products. It was determined that a need certainly exists to train members of the workforce in fabricating techniques, not in metals, but also in those materials displacing metals i.e. composites.

Problems Encountered

The biggest problem encountered was the lack of any previous research done in developing a curriculum for composites. The industry is obviously associated with space technologies and previously unknown to other sectors of manufacturing. Much of the industry is still evolving and many industry standards simply do not exist.

Recommendations/Suggested Follow-up

It is recommended that the Pennsylvania Department of Education contract additional curriculum projects in the area of composites and other advanced materials. It is additionally recommended that those LEA developing such a curriculum, be invited to meet together to review the materials developed. This will certainly be an area that all schools should consider in future programs.

Products Produced

The curriculum produced includes a competency listing, performance objectives, learning activities and suggested projects including project plans for a boat trailer.

How the Results of the Project Will Be Used

The results will be used to incorporate the composite curriculum into both the secondary and post-secondary/adult curriculum will become an intergal part of the metal fabrication in the daytime and individual courses in the adult education program.

Disemination of Information

All industries using composites will be provided a copy of the curriculum along with all school districts in Bedford County. An additional copy will be forwarded to Appalachia Intermediate Unit 08.

Positive Outcomes

The school has a draft articulation agreement with Engineering department at UPJ as a result of this project. This would not have happened without the curriculum development grant.

SECTION V - ATTACHMENTS/APPENDICES

SECTION V-a - COMPETENCIES

COMPETENCIES FOR ADVANCED MATERIALS AND PROCESSES

I. Unit Title: Introduction to Advanced Materials used in Manufacturing and Fabrication

Competency/Task

1. Identifying ceramic fibers
2. Identifying carbon fibers
3. Identifying aramid fibers
4. Identifying hollow glass fibers
5. Identify boron fibers
6. Identifying polyvinyl alcohol fibers
7. Identifying crystal whisker fibers of aluminum oxide, beryllium oxide, magnesium oxide and silicon carbide
8. Identifying metal fibers (steel, aluminum, copper, nickel)
9. Identifying graphite fibers
10. Identifying fiberglass
11. Define the term plastics
12. Identify sources of plastics
13. Identify a monomer
14. Identify a polymer
15. Identify thermoplastics
16. Identify thermosetting plastics
17. Identify 3 broad areas of the plastics industry - production of resins, processing, and fabricating/finishing
18. Identifying composite materials
19. Defining reinforced fiberglass plastic
20. Identifying aluminum alloys
21. Identifying titanium
22. Identifying thermalplastic fibers (monofilaments, etc)

II. Unit Title: Characteristics of Composite Materials

Competency/Task

1. Identifying "Resins" and their qualities
2. Identifying "Fillers" and their qualities
3. Defining "Reinforcements" and their qualities
4. Identifying various "Laminate" materials, woods, paper, etc.
5. Identifying a surface veil
6. Identifying solvents
7. Using lubricants
8. Using plasticizers
9. Using stabilizers
10. Using antistatic agents
11. Using pigments
12. Using catalysts and promoters
13. Using flame - retardant additives
14. Defining viscosity - resistance to flow
15. Identifying the chemical resistance of polyesters
16. Identifying the environmental properties of composites
17. Identifying electrical properties of composites
18. Identifying mechanical properties of composities
19. Comparing strengths of composites to other materials

III. Unit Title: Design Considerations: Processing Composite Materials

Competency/Task

1. Identifying the sequence of manufacturing operations
2. Identify 8 basic design considerations of composites/plastics
3. Define CAD/CAM

4. Define CAMM

5. Identifying a prototype

6. Simulating performance and service tests

7. Define the importance of material shrinkage

8. Identify dimensional tolerance

9. Identify parting lines

10. Identify reinforced plastics molding processes

IV. Unit Title: Design and Drafting: CAD Utilization

1. Define CAD, CAM, CIM

2. Name the two main parts of a CAD system

3. Name the five basic hardware components

4. Identify the CPU, and the input, display, storage, and output devices

5. Turn on computer and start CAD software

6. Define the term "window"

7. Identify the drawing window

8. Identify the menu window

9. Identify the status window

10. Identify the cursor tracking window

11. Identify the history line and define its purpose

12. Identify the prompt line

13. Explain the menu tree structure

14. Define the positive axes for view coordinates

15. Define: grid, snap, cursor tracking, redraw, delete, undelete, and autoscale.

16. Demonstrate the immediate mode commands for the items defined above.

17. Define entity types used in CAD

18. Create lines with endpoints, string, and parallel

options using cursor, end entity, intersection, and along line positioning

19. Demonstrate setting line type
20. Create rectangle and change scale of display and position of center
21. Create points using polar delta positioning
22. Create circles using all options on circle menu
23. Demonstrate appropriate use of all options in display menu
24. Create arcs using all options in acr menu
25. Create fillets and chamfers
26. Create horizontal and vertical lines
27. Create parallel and perpendicular lines
28. Create lines tangent to circles and arcs
29. Create lines at an angle to a reference line
30. Create 2D cubic open and closed splines
31. Demonstrate deleting entities from a drawing using the selection menu options single, chain, window, group, and all display
32. Demonstrate trimming and extending lines, arcs, and circles
33. Demonstrate correcting, altering, adjusting, and repositioning entities using the edit menu
34. Demonstrate breaking entities
35. Demonstrate previously deleted entities
36. Demonstrate moving entities with the box move option
37. Demonstrate grouping options (make, add to, degroup, delete, list)
38. Demonstrate creating points along a line, acr, or circle
39. Demonstrate setting all line types and changing line types of entities

40. Demonstrate changing all line widths and changing line widths of entities

41. Demonstrate setting pen# and changing pen# of entities

42. Demonstrate making levels active and inactive

43. Demonstrate making levels visible and invisible

44. Demonstrate moving entities to different levels

45. Demonstrate listing levels

46. Demonstrate turning grid and snap on and off

47. Demonstrate setting grid and snap X and Y values

48. Demonstrate aligning grid and/or snap to an entity

49. Demonstrate accessing the teach system

50. Demonstrate saving, loading and listing drawing part files

51. Demonstrate creating, retreiving and listing pattern files

52. Demonstrate saving and loading drawings as DXF files

53. Demonstrate saving plot files

54. Demonstrate plotting of a drawing both on-line and via plot files

55. Demonstrate using a printer to produce a hardcopy of a drawing

56. Properly dimension a detail drawing

57. Demonstrate the use of notes and labels on a drawing

58. Demonstrate setting units, tolerances, and number of decimal places for dimensioning

51. Demonstrate editing notes, labels, and dimensions

52. Demonstrate changing characteristics of dimensions, notes, and labels using the update option

53. Demonstrate verifying the attributes of an entity

54. Demonstrate verifying the coordinates of an entity

55. Demonstrate verifying the distance between two

positions, two lines, and a position and an entity

56. Verify an angle

57. Verify the area and centroid of an enclosed figure

58. Verify the polar moment of inertia of an enclosed area

59. Demonstrate crosshatching a section view of a drawing

60. Define the terms translate, rotate, scale, and mirror

61. Describe the differences between the move, copy, and join options

62. Demonstrate translating and entity using the trans-r and trans-a options with move, copy, and join

63. Demonstrate rotation of an entity using the 2D rotate option with move, copy and join

64. Demonstrate scaling using move, copy and join

65. Demonstrate mirroring using move, copy and join

66. Define the term wire frame model

67. Demonstrate creating a 3D wireframe model of an object by extruding a two dimensional drawing

68. Demonstrate the use of pattern files to create a four view drawing

69. Demonstrate the use of delection and edition functions to finalize the four view drawing

70. Demonstrate the use of 3D CAD capability to create an assembly drawing

V. Unit Title: Safety

Competency/Task

1. List five forms of chemical hazards

2. List five possible effects of chemical hazards on humans

3. List 5 physical hazards

4. List 2 biological hazards

5. Identify the "Lack of Toxicity" of finished composites/plastics

6. Identify the health hazards of monomers and composites/plastics ingredients

7. Identify the proper storage of chemicals

8. List the three greatest fire toxicities of plastics

9. Demonstrate the proper procedure for mixing promoters and catalysts into resins

10. Identify the explosivesness of plastics dust

11. Identify the need for a dust collection system

12. Identify water cooling as a way to diminish dust

13. Identify the need for proper light covers

14. Identify a proper ventilation system

15. Identify 6 types of proper clothing

16. List the need to avoid sources of sparks

17. List the fact that composites/plastics can be self-extinguishing

18. List the proper type of fire extinguisher for plastics/metal composites

19. List 6 methods of preventing equipment accidents

20. List safety rules for each piece of equipment used in composites fabrication/advanced metals fabrication

21. Define the term "OSHA"

VI. Unit Title: Machine Processes

Competency/Task

1. Compare plastics/composites machining to that of metal/wood

2. Demonstrate proficiency in adding, subtracting, multiplying and dividing decimal numbers

3. Compare the machining of thermoplastics and thermosetting plastics

4. Read vernier calipers

5. Read micrometer

6. Read blueprints

7. List the types of blade/tool materials for composites/plastics

8. List the types of cooling agents used

9. List 4 benefits of cooling agents

10. Grind the normal rake angle on blades and twist drills for plastics/composites

11. List the proper "set" on saw blades

12. List the proper number of teeth per centimeter for cutting thick and thin plastics with the circular (table) saw

13. List the proper number of teeth per centimeter for a bandsaw

14. List the best type of bandsaw blade to use

15. Identify the reason for using oversized twist drills on plastics-based composites

16. Demonstrate use of bushings for drilling

17. Demonstrate proper feeding techniques on machines

18. Demonstrate proper speeds on machines

19. Demonstrate proper clamping and support of materials

20. Cut "veiled" materials with the "seen" side up

21. Demonstrate precision cutting techniques (clamping and second cuts)

22. Identify expected minimum tolerances

23. Identify the proper type of equipment, air-powered for routers and grinders

24. Identify the need to avoid excess pressure in machining composites

25. Identify the proper grit for grinding wheels for composites

26. Identify the best type of machine punch cutting-tip profile

27. Identify the need for oversized punches for composites/reinforced plastics

28. Identify the need for lubricants for drilling and punching operations

29. Identify the punch tolerances of mat-reinforced pastics as compared to those of roving-reinforced plastics

30. Identify the fact that larger holes punch cleaner

31. Identify the operation of shearing composites

32. Identify the need to shear composites perpendicular to the grain of the fibers

33. Demonstrate proper lathe threading techniques

34. Demonstrate the use of proper lubricants when machine tapping and threading

35. Demonstrate the proper amount of material to be removed during lathe threading

36. Demonstrate the proper threads to use in lathe threading

37. Demonstrate the set up of a simple jig or multiple blade set-up

38. Demonstrate climb - cutting with the milling machine

39. Define laser cutting

40. Define thermal cutting

41. Define hydrodynamic cutting

VII. Unit Title: Integrating CAD/CAM with Advanced Materials Machining and Fabricating Processes.

1. Define CAM

2. Define CNC

3. Identify Cartesian coordinate system

4. Identify coordinates of points in 2 dimensional coordinate system

5. Identify coordinate of points in 3 dimensional coordinate system

6. Define basicCNC commands (rapid, linear, clockwise, and

counterclockwise motions)

7. Define a block

8. Define a G-codes

9. Define M-codes

10. Idenfity rapid, linear, clockwise, and counterclockwise CNC commands

11. Beaware of and understand current general machine shop safety practices and procedures as well as current specific cautions and safety practices and procedures that apply to the specific CNC machine tool to be used by the instructor and student.

12. Select and load appropriate cutting tool into machine

13. Align machine and tool to origin

14. Select and set proper spindle speed on machine tool

15. Initiate CAM software

16. Select appropriate CAD system for desired drawing

17. Load a DXF file onto system

18. Send generated CNC program to machine and disk

19. Utilize the CAM software to select tool diameter

20. Position tool in starting position by aligning to CAD drawing

21. Demonstrate moving tool to enter work

22. Demonstrate defining cutting path utilizing the existing CAD geometry

23. Return tool to origin

24. Select and load appropriate cutting tool into machine

25. Align machine and tool to origin

26. Select and set proper spindle speed on machine tool

27. Initiate CNC editor software on computer

28. Load existing CNC program

29. List program to verify correctness

30. Initiate CNC machine control unit (MCU)

31. Transfer CNC program from computer to MCU

32. Initiate control menu

33. Run CNC program on machine tool

34. Release all power to CNC machine tool

35. Exit control menu

36. Exit CNC editor software

37. Remove workpiece from machine and inspect

VIII. Unit Title: Fabrication Processes

Competency/Task

1. Identify adhesive bonding

2. List 7 advantages of adhesives

3. List 1 disadvantage of adhesives

4. Identify the characteristics of epoxies, acrylics and polyesters

5. Identify cohesive bonding

6. Demonstrate surface preparation for adhesives

7. Demonstrate bonding of composites with adhesives

8. Demonstrate bonding of advanced materials with adhesives

9. Demonstrate cohesive bonding of advanced materials, i.e., welding of aluminum alloys

10. Compare 5 properties of adhesives to the same properties of mechanical fasteners

11. Identify the advantages of using mechanical fasteners and adhesives in conjunction with each other

12. List 6 mechanical fasteners

13. Demonstrate 6 types of mechanical fastening

14. Identify 14 joint designs

15. Demonstrate 5 types of joint design in composite/advanced materials

16. Identify 4 types of joint stress

17. Identify the 2 best joints to use with respect to stress

18. List 5 types of structural joints

19. Demonstrate the fabrication of 2 structural joints

IX. Unit Title: Finishing Operations

Competency/Task

1. List 5 types of finishes for composites/advanced materials

2. List three steps in surface preparation of composites/advanced materials

3. Demonstrate surface preparation techniques, i.e., solvent wiping, sanding, sand blasting

4. Identify the need to follow the finish manufacturer's recommendations

5. Demonstrate applying a finish to composites/advanced materials

X. Unit Title: "Other" Technical Occupations in the Composite Materials Industry

Competency/Task

1. Identify engineers

2. Identify chemists

3. Identify machinists - for mold making

4. Identify electroplating technicians - for mold

5. Identify quality control personnel

6. Conclude course with field trip to a composites manufacturing/advanced materials factory

SECTION V-b - PERFORMANCE OBJECTIVES

PERFORMANCE OBJECTIVES FOR ADVANCED MATERIALS AND PROCESSES

I. Unit Title: Introduction to advanced materials used in manufacturing and fabrication.

1. After being shown the characteristics of 13 advanced materials, students will identify them with at least 90% proficieny.

2. After reading about and discussing the properties of plastics, students will define the term "plastics" with at least 90% proficiency.

3. After reading about and discussing the properties of plastics, students will identify the sources of plastics with at least 80% proficiency.

4. After reading about and discussing the properties of plastics, students will identify the terms monomer with at least 80% proficiency.

5. After reading about and discussing the properties of plastics, students will identify the term polymer with at least 80% proficiency.

6. After reading about and discussing the properties of plastics, students will be able to identify 1 minor property of thermoplastic material with at least 80% proficiency.

7. After reading about and discussing the properties of plastics, students will identify 1 major property of thermosetting plastic with at least 90% proficiency.

8. After reading about and discussing the plastics industry, students will be able to identify 3 broad areas of the plastics industry with at least 80% proficiency.

9. After reading about and discussing composite materials, students will define composite materials with at least 90% proficiency.

10. After reading about and discussing composite materials, students will identify 3 composite materials with at least 90% proficiency.

11. After reading about and discussing composite materials, students will define fiberglass reinforced plastics with at least 90% proficiency.

12. After reading about and discussing advanced materials, students will identify aluminum alloys with at least 90% proficiency.

II. Unit Title: Characteristics fo composite materials.

1. After reading about and discussing composite/plastic materials, students will identify "resins" with at least 90% proficiency.

2. After reading about and discussing composite/plastic materials, students will identify "fillers" with at least 90% proficiency.

3. After reading about and discussing composites, students will define reinforcements with at least 90% proficiency.

4. After discussing composites, students will list 3 laminate materials with at least 90% proficiency.

5. After discussing composites, students will identify a surface veil with 90% proficiency.

6. After reading about and discussing composites/plastics, students will identify solvents with at least 90% proficiency.

7. After reading about and discussing composites/plastics, students will identify lubricants used in composites/plastics with at least 80% proficiency.

8. After reading about and discussing plastics, students will identify plasticizers with at least 80% proficiency.

9. After reading about and discussing composites/plastics, students will identify stabilizers with at least 90% proficiency.

10. After reading about and discussing plastics, students will identify anti-static agents with at least 80% proficiency.

11. After reading about and discussing composites/plastics, student will define "pigments" with at least 90% proficiency.

12. After reading about and discussing composites/plastics, students will define catalysts with at least 90% proficiency.

13. After reading about and discussing composites/plastics, students will define promoters with at least 90% proficiency.

14. After reading about and discussing composites, students

will define flame-retardant additives with at least 80% proficiency.

15. After reading about and discussing composites/plastics, students will define viscosity with at least 80% proficiency.

16. After discussing the properties of composites, students will identify the chemical resistance of polyesters with at least 90% proficiency.

17. After discussing the properties of composites, students will identify 3 environmental properties of composites with at least 80% proficiency.

18. After discussing the properties of composites, students will identify two electrical properties of composites with at least 90% proficiency.

19. After discussing the properties of composites, students will identify 5 mechanical properties of composites with at least 90% proficiency.

20. After discussing the properties of composites, students will compare the strengths and weights of composites with the same realities of 4 other materials with at least 80% accuracy.

III. Unit Title: Design considerations: processing composite materials

1. After discussing manufacturing students will list 7 sequential steps in manufacturing with at least 80% proficiency.

2. After reading and discussing the design considerations of composites/plastics, students will identify 8 basic design considerations for composites with at least 80% accuracy.

3. After watching the operation of and discussing CAD/CAM, students will define CAD/CAM with 90% accuracy.

4. After discussing composites/plastics, students will define CAMM with at least 80% accuracy.

5. After reading and discussing the design considerations for composites/plastics, students will identify a prototype with at least 80% accuracy.

6. After discussing design considerations and viewing/participating in materials tests for composites/advanced materials students will list 5

types of performance and service tests for composites/advanced materials with at least 80% accuracy.

7. Given instruction on reading a materials tester and a demonstration on materials testing, students will test 3 composites and 1 advanced material and list their tensile strengths with at least 80% proficiency.

8. After reading and discussing the design considerations for plastics, students will define the importance of material shrinkage in molding operations with at least 80% accuracy.

9. After discussing design considerations for composites, students will define dimensional tolerances with at least 80% accuracy.

10. After discussing pultruding processes, students will identify "parting lines" with at least 80% accuracy.

11. After reading about and discussing composites molding operations, students will identify 2 such molding operations with at least 90% accuracy.

IV. Unit Title: Design and Drafting: CAD Utilization

1. After reading about and discussing the terms CAD, CAM, CIM, the student will be able to define these terms.

2. After reading about and discussing the two main parts of a CAD system, the student will be able to list the two main parts of a CAD system.

3. After reading about and discussing the five basic hardware components, the student will be able to list the components.

4. After reading about and discussing the CPU, and the input, display, storage, and output devices, the student will be able to identify them.

5. After a demonstration by the instructor, the student will be able to turn on the computer and initiate the CAD software.

6. After reading about and discussing the term "window", the student will be able to define the term.

7-12 After reading about and discussing the window areas on the CAD screen display, the student will be able to identify the following window areas: drawing window, menu window, status window, cursor tracking window, history line, and prompt line.

13. After reading about and discussing the menu tree structure, the student will be able to describe the menu treee structure.

14. After reading about and discussing the positive axes for view coordinates, the student will be able to sketch the positive axes for view coordinates.

15. After reading about and discussing these terms, the student will be able to define: grid, snap, cursor tracking, redraw, delete, undelete, and autoscale.

16. Provided with a CAD workstation, the student will be able to demonstrate the immediate mode commands for grid on/off, snap on/off, cursor tracking on/off, single delete, recall last, and autoscale zoom.

17. After reading about and discussing entity types used in CAD, the student will be able to list and describe the entity types.

18. Provided with a CAD workstation, the student will be able to create lines with endpoints, string, and parallel options using cursor, end entity, intersection, & along line positioning while creating a new CAD drawing or modifying an existing CAD drawing.

19. Provided with a CAD workstation, the student will be able to demonstrate setting line types while creating a new CAD drawing or modifying an existing CAD drawing.

20. Provided with a CAD workstation, the student will be able to create a rectangle and change the scale of the display and the position of center of display while creating a new CAD drawing or modifying an existing CAD drawing.

21. Provided with a CAD workstation, the student will be able to create points using polar and delta positioning while creating a new CAD drawing or modifying an existing CAD drawing.

22. Provided with a CAD workstation, the student will be able to create circles using all options on circle menu while creating a new CAD drawing or modifying an existing CAD drawing.

23. Provided with a CAD workstation, the student will be able to demonstrate appropriate use of all options in display menu while creating a new CAD drwaing or modifying an existing CAD drawing.

24. Provided with a CAD workstation, the student will be

able to create arcs using all options in acr menu while creating a new CAD drawing or modifying an existing CAD drawing.

25. Provided with a CAD workstation, the student will be able to create fillets and chamfers while creating a new CAD drawing or modifying an existing CAD drawing.

26. Provided with a CAD workstation, the students will be able to create horizontal and vertical lines while creating a new CAD drawing or modifying an existing CAD drawing.

27. Provided with a CAD workstation, the student will be able to create parallel and oerpendicular lines while creating a new CAD drawing or modifying an existing CAD drawing.

28. Provided with a CAD workstation, the student will be able to create lines tangent to circles and arcs while creating a new CAD drawing or modifying an existing CAD drawing.

29. Provided with a CAD workstation, the student will be able to create lines at an angle to a reference line while creating a new CAD drawing or modifying an existing CAD drawing.

30. Provided with a CAD workstation, the student will be able to create 2D cubic open and closed splines while creating a new CAD drawing or modifying an existing CAD drawing.

31. Provided with a CAD workstation, the student will be able to demonstrate deleting entities from a drawing using the selection menu options single, chain, window, group, and all display while creating a new CAD drawing or modifying an existing CAD drawing.

32. Provided with a CAD workstation, the student will be able to demonstrate trimming and extending lines, arcs, and circles while creating a new CAD drawing or modifying an existing CAD drawing.

33. Provided with a CAD workstation, the student will be able to demonstrate correcting, alterning, adjusting, and repositioning entities using the edit menu while creating a new CAD drawing or modifying an existing CAD drawing.

34. Provided with a CAD workstation, the student will be able to demonstrate breaking entities while creating a new CAD drawing or modifying an existing CAD drawing.

35. Provided with a CAD workstation, the student will be able to demonstrate recalling previously deleted entities while creating a new CAD drawing or modifying an existing CAD drawing.

36. Provided with a CAD workstation, the student will be able to demonstrate moving entities with the box move option while creating a new CAD drawing or modifying an existing CAD drawing.

37. Provided with a CAD workstation, the students will be able to demonstrate grouping options (make, add to, degroup, delete, list) while creating a new CAD drawing or modifying an existing CAD drawing.

38. Provided with a CAD workstation, the students will be able to demonstrate creating points along a line, arc, or circle while creating a new CAD drawing or modifying an existing CAD drawing.

39. Provided with a CAD workstation, the student will be able to demonstrate setting all line types and changing line types of entities while creating a new CAD drawing or modifying an existing CAD drawing.

40. Provided with a CAD workstation, the student will be able to demonstrate changing line widths and changing line widths of entities while creating a new CAD drawing or modifying an existing CAD drawing.

41. Provided with a CAD workstation, the student will be able to demonstrate setting pen# and changing pen# of entities while creating a new CAD drawing or modifying and existing CAD drawing.

42. Provided with a CAD workstation, the students will be able to demonstrate making levels active and inactive while creatig a new CAD drawing or modifying an existing CAD drawing.

43. Provided with a CAD workstation, the student will be able to demonstrate making levels visible and invisible while creating a new CAD drawing or modifying an existing CAD drawing.

44. Provided with a CAD workstation, the student will be able to demonstrate moving entities to different levels while creating a new CAD drawing or modifying an existing CAD drawing.

45. Provided with a CAD workstation, the student will be able to demonstrate listing levels while creating a new CAD drawing or modifying an existing CAD drawing.

46. Provided with a CAD workstation, the student will be able to demonstrate turning grid and snap on and off while creating a new CAD drawing or modifying an existing CAD drawing.

47. Provided with a CAD workstation, the student will be able to demonstrate setting grid and snap X and Y valves while creating a new CAD drawing or modifying an existing CAD drawing.

48. Provided with a CAD workstation, the student will be able to demonstrate aligning grid and/or snap to an entity while creating an entity while creating a new CAD drawing or modifying an existing CAD drawing.

49. Provided with a CAD workstation, the student will be able to demonstrate accessing the teach system while creating a new CAD drawing or modifying an existing CAD drawing.

50. Provided with a CAD workstation, the student will be able to demonstrate saving, loading and listing drawing part files while creating a new CAD drawing or modifying an existing CAD drawing.

51. Provided with a CAD workstation, the student will be able to demonstrate creating, retreiving and listing pattern files while creating a new CAD drawing or modifying an existing CAD drawing.

52. Provided with a CAD workstation, the student will be able to demonstrate saving and loading drawings as DXF files while creating a new CAD drawing or modifying an existing CAD drawing.

53. PRovided with a CAD workstation, the student will be able to demonstrate saving plot files while creating a new CAD drawing or modifying an existing CAD drawing.

54. Provided with a CAD workstation, the student will be able to demonstrate plotting of a drawing both on-lineand via plot files while creating a new CAD or modifying an existing CAD drawing.

55. Provided with a CAD workstation, the student will be able to demonstrate using a printer to produce a hardcopy of a drawing while creating a new CAD drawing or modifying an existing CAD drawing.

56. Provided with a CAD workstation, the student will be able to properly dimension a new or existing CAD detail drawing.

57. Provided with a CAD workstation, the student will be

able to demonstrate the use of notes and label on a new or existing CAD drawing.

58. Provided with a CAD workstation, the student will be able to demonstrate setting units, tolerences, and number of decimal places for dimensioning while creating a new CAD drawing or modifying an existing CAD drawing.

59. Provided with a CAD workstation, the student will be able to demonstrate editing notes, labels, and dimensions while creating a new CAD drawing or modifying an existing CAD drawing.

60. Provided with a CAD workstation, the student will be able to demonstrate changing characteristics of dimensions, notes, and labels using the update option while creating a new CAD drawing or modifying an existing CAD drawing.

61. Provided with a CAD workstation, the student will be able to demonstrate verifying the attributes of an entity while creating a new CAD drawing or modifying an existing CAD drawing.

62. Provided with a CAD workstation, the student will be able to demonstrate verifying the coordinates of an entity while creating a new CAD drawing or modifying an existing CAD drawing.

63. Provided with a CAD workstation, the student will be able to demonstrate verifying the distances between two positions, two lines, and a position and an entity while creating a new CAD drawing or modifying an existing CAD drawing.

64. Provided with a CAD workstation, the student will be able to verify an angle while creating a new CAD drawing or modifying an existing CAD drawing.

65. Provided with a CAD workstation, the student will be able to verify the area and centroid of an enclosed figure while creating a new CAD drawing or modifying an existing CAD drawing.

66. Provided with a CAD workstation, the student will be able to verify the polar moment of inertia of an enclosed area while creating a new CAD drawing or modifying an existing CAD drawing.

67. Provided with a CAD workstation, the student will be able to demonstrate crosshatching a section view of a new or existing CAD drawing.

68. After reading about and discussing the terms translate, rotate, scale, and miror, the student will define these terms with 90% accuracy.

69. Affter reading and discussing the differences between the move, copy, and join options the student will describe the differences between these terms.

70. Provided with a CAD workstation, the student will be able to demonstrate translating an entity using the trans-r and trans-a options with the move, copy, and join while creating a new CAD drawing or modifying an existing CAD drawing.

71. Provided with a CAD workstation, the student will be able to demonstrate rotation of an entity using the 2D rotate option with move, copy and join while creating a new CAD drawing or modifying an existing CAD drawing.

72. Provided with a CAD workstation, the student will be able to demonstrate scaling using move, copy and join while creating a new CAD drawing or modifying an existing CAD drawing.

73. Provided with a CAD workstation, the student will be able to demonstrate miroring using move, copy and join while creating a new CAD drawing or modifying an existing CAD drawing.

74. After reading about and discussing the term wireframe model, the student will be able to define the term.

75. Provided with a CAD workstation, the student will be able to demonstate creating a 3D wireframe model of an object by extruding a two dimensional drawing.

76. Provided with a CAD workstation, the student will be able to demonstrate the use of pattern files to create a four view CAD drawing.

77. Provided with a CAD workstation, the student will be able to demonstrate the use of deletion and editinng functions to finalize the four view CAD drawing.

78. Provided with a CAD workstation, the student will be able to demonstrate the use of 3D CAD capabilities to create an assembly drawing.

V. Unit Title: Safety

1. After reading about and discussing safety, students will list 5 forms of chemical hazards with at least 80% accuracy.

2. After reading about and discussing safety, students will list 5 possible effects of chemical hazards on humans with at least 80% accuracy.

3. After reading about and discussing safety, students will list 5 physical hazards associated with advanced materials/ plastics with at least 80% accuracy.

4. After reading about and discussing safety, students will list 2 biological hazards associated with composites/plastics with at least 80%.

5. After reading and discussing safety, students will identify the lack of toxicity of finished plastics with at least 80% accuracy.

6. After consulting a chart on "Health Hazards of Selected Materials," students will identify the health hazards of 4 composites materials with at least 80% accuracy.

7. After reading about and discussing safety, students will identify the proper storage of chemicals with at least 90% accuracy.

8. After reading about and discussing safety, students will list the three greatest fire toxicities of plastics with at least 80% accuracy.

9. After reading about and observing the proper way to mix promoters and catalysts, students will mix promoters and catalysts into a small amount of resin with 100% accuracy.

10. After reading about and discussing safety, students will identify the explosiveness of composites/plastics dust with at least 80% accuracy.

11. After reading about and discussing safety, students will identify 4 methods of combating dust/fumes in a pultruding/ composites factory with at least 90% accuracy.

12. After reading about and discussing safety, students will list 6 types of protective gear/clothing to be worn in a shop environment with at least 90% accuracy.

13. After reading about and discussing safety, students will list the need to prevent sparks near composites dust and chemicals with at least 90% accuracy.

14. After reading about and discussing safety, students will list 1 way composites/plastics can be made flame retardant with at least 80% accuracy.

15. After reading about and discussing safety, students will list the proper type of fire extinguishers for plastics composites/metal with at least 90% accuracy.

16. After reading about and discussing safety, students will list 6 methods of preventing equipment accidents with at least 90% accuracy.

17. After reading about and discussing safety, students will list the safety rules for each piece of equipment used in composites fabrication/advanced metals fabrication with at least 100% accuracy.

18. After reading about and discussing safety, students will define the term "OSHA."

VI. Unit Title: Machine processes

1. After reading about and discussing machine processes, students will compare composites/plastics machining to that of metal/wood with at least 80% accuracy.

2. After reading about and discussing machine processes, students will compare the machining of thermoplastics and thermosetting plastics with at least 80% accuracy.

3. After viewing demonstrations and going through excesses in decimal math, students will list answers to addition, subtraction, multiplication and division decimal problems with at least 90% accuracy.

4. After discussing and observing instrument reading, students will measure ten samples with the vernier calipers with at least 90% accuracy.

5. After discussing and observing instrument reading, students will measure ten samples with the micrometer with at least 90% accuracy.

6. After discussing and observing instrument reading, students will make measurements on all projects with all hand measuring tools and instruments with at least 80% accuracy.

7. After discussing, reading about, and observing blueprint reading, students will read blueprints (technical drawings) with at least 80% accuracy.

8. After discussing the types of blade/tool materials for composites, students will list 3 types of materials used for blade/drill bits with at least 90% accuracy.

9. After reading about, observing and discussing the types of cooling agents used, students will list 2 types of

cooling agents with at least 80% accuracy.

10. After reading about and discussing the types of cooling agents, students will list 4 benefits of cooling agent use with at least 80% accuracy.

11. After discussing and observing the grinding of rake angles on twist drills, students will grind the normal rake angles on twist drills for composites (a regular angle)/plastics (a zero angle) with at least 80% accuracy.

12. After discussing and reading about the proper set on saw blades, students will identify the proper set for none composites (none)/plenty plastics (plenty) with at least 80% accuracy.

13. After discussing and reading about machine processes, students will list the proper number of teeth per centimeter for cutting thick and thin plastics with the circular saw with at least 80% accuracy.

14. After reading about and discussing machine processes, students will list the proper number of teeth per centimeter for a bandsaw with at least 80% accuracy.

15. After discussing machine processes, students will list the best type of bandsaw blade to use for composites with at least 80% accuracy.

16. After reading about and discussing machine processes, students will identify the need for using oversized twist drills, on composites with at least 90% accuracy.

17. After discussing drilling of composites, students will drill with bushings (to prevent fractures) with at least 80% success.

18. Given a demonstration and text information, students will feed their machines with the proper speed as shown by the instructor for the material being used to prevent frayed edges.

19. Given a demonstration and text information, students will set the correct speed on their machines with at least 80% accuracy.

20. After receiving machining processes demonstrations, students will properly clamp and support their materials for machining with 100% success.

21. After receiving machining processes demonstrations, students will cut "veiled" materials with the "seen" side up with at least 80% success.

22. After receiving demonstrations on precision-cutting techniques, students will precision-cut composites using clamping and second-cut techniques with at least 90% accuracy.

23. After discussing machining techniques, students will identify expected minimum tolerances with at least 80% accuracy.

24. After discussing machining processes, students will identify the best type of machine, air powered, for routers and grinders with at least 80% accuracy.

25. After discussing and viewing machining techniques, students will identify the need to avoid excess pressure in composites machining with at least 90% accuracy.

26. After discussing machining techniques, students will identify the proper grit for grinding wheels for composites with at least 80% accuracy.

27. After discussing machine punching operations, students will identify the best type of punch cutting-tip profile for composites with at least 90% accuracy.

28. AFter discussing punching operations, students will identify the need to use oversized punches in composites with at least 90% accuracy.

29. After discussing drilling and punching operations in composites, students will identify the need for lubricants in drilling and punching with at least 90% accuracy.

30. After discussing punching operations, students will identify the punch tolerances of mat-reinforced plastics as compared to those of roving-reinforced plastics with at least 80% accuracy.

31. Given a demonstration on punching composites, students will identify the fact that larger holes punch cleaner with at least 90% accuracy.

32. Given a lecture on composites machining processes, students will identify the operation of shearing composites with at least 80% accuracy.

33. Given a lecture on shearing composites, students will identify the need to shear composites perpendicular to the grain of the fibers with at least 80% accuracy.

34. After viewing machining demonstrations, students will

successfully follow the proper sequence of lathe operations in thread-cutting as observed by the instructor.

35. After viewing machining demonstrations, students will properly lubricate their materials when thread-cutting to cause a smooth-running operation.

36. After viewing threading operations, students will remove only 75% of the composite threads during lathe thread-cutting with at least 90% accuracy.

37. After viewing threading operations, students will select the proper form of threads to cut on the lathe with at least 90% success.

38. After discussing jigs and fixtures, students will build/set up a simple jig and/or multiple blade set-up with at least 90% accuracy.

39. After reading about and viewing climb-cutting operations, students will climb cut plastics/advanced materials with at least 90% accuracy on the milling machine.

40. After reading about and discussing laser cutting, students will define laser cutting with at least 90% accuracy.

41. After reading about and discussing thermal cutting, students will define thermal cutting with at least 80% accuracy.

42. After reading about and discussing hydrodynamic cutting, students will define hydrodynamic cutting with at least 90% accuracy.

VII. Unit Title: Integrating CAD/CAM with Advanced Materials Machining and Fabricating Processes.

1. After reading about and discussing Computer-Aided-Manufacturing (CAM), the student will be able to define CAM.

2. After reading about and discussing Computer-Numerical-Control (CNC), the student will be able to define CNC.

3. After reading about and discussing Cartesian coordinate systems, the student will be able to identify a Cartesian coordinate system.

4. After reading about and discussing how to identify coordinates of a points in a 2 dimensional coordinate system, the student will be able to plot points, and

determine coordinates of points.

5. After reading about and discussing how to identify coordinates of a points in a 3 dimensional coordinate system, the student will be able to plot points, and determine coordinates of points.

6. After reading about and discussing the basic CNC commands (rapid, linear, clockwise, and counter-clockwise motions), the student will be able to define these commands.

7. After reading about and discussing blocks, the student will be able to define the term.

8. After reading about and discussing G-codes, the student will be able to define G-codes.

9. After reading about and discussing M-codes, the student will be able to define basic M-codes, and identify them within a block.

10. After reading about and discussing rapid, linear, clockwise, and counter-clockwise CNC commands, the student will be able to identify these commands by their G-codes within a block.

11. After reading about and discussing general machine shop safety and specific safety practies and procedures for the CNC mail, the student will be able to operate the machine tool safety by following these safety guidelines.

12. Provided with a CNC mill, appropriate end mill, and appropriate wrenches, the student will be able to select and load appropriate cutting tool into machine.

13. Provided with a 1/2" dowel pin and 3/8" alginment pin, the student will be able to align the CNC machine and tool to the origin designated by the instructor.

14. Provided with a CNC mill, the student will be able to select and set the proper spindle speed on the CNC machine tool.

15. Provided with a CAD workstation and CAM software, the student will be able to initiate CAM software.

16. Provided with a CAD workstation, CAM software, and the appropriate CAD drawing as a DXF file, the student will be able to select appropriate CAD system for desired drawing.

17. Provided with a CAD workstation, CAM software, and the

appropriate CAD drawing as a DXF file, the student will be able to load a DXF file onto the CAM system.

18. Provided with a CAD workstation, CAM software and a CNC mill, the student will be able to send the generated CNC program to the CNC machine and save the CNC program on a diskette.

19. Provided with a CAD workstation, CAM software and a CNC mill, the student will be able to utilize the CAM software to select the apporpriate tool diameter.

20. Provided with a CAD workstation, CAM software and a CNC mill, the student will be able to position the cutting tool in starting position by aligning to the CAD drawing.

21. Provided with a CAD workstation, CAM software and a CNC mill, the student willl be able to demonstrate moving the cutting tool to enter the workpiece.

22. Provided with a CAD workstation, CAM software and a CNC mill the student will be able to demonstrate defining the cutting path utilizing the existing CAD geometry.

23. Provided with a CAD workstation, CAM software and a CNC mill, the student will be able to return the cutting tool to back to the designated origin, shut down the CNC mill, and exit the CAM software.

24. Provided with a CNC mil, appropriate end mill, and appropriate wrenches, the student will be able to select and load appropriate cutting tool into machine.

25. Provided with a 1/2" dowel pin and 3/8" alignment pin, the student will be able to align the CNC machine and tool to the origin designated by the instructor.

26. PRovided with a CNC mill, the student will be able to select and set the proper spindle speed on the CNC machine tool.

27. Provided with a CAD workstation and CAM software, the student will be able to initiate CNC editor software on computer.

28. Provided with a CAD workstation and CAM software, the student will be able to load an existing CNC program onto the CNC editor.

29. Provided with a CAD workstation and CAM software, the student will be able to list the CNC program to verify the correctness of the loading procedure.

30. Provided with a CAD workstation, CAM software and CNC machine tool with control unit, the student will be able to initiate CNC machine control unit (MCU).

31. Provided with a CAD workstation, CAM software and CNC machine tool with control unit, the student will be able to transfer the CNC program from the computer to the MCU.

32. Provided wtih a CAD wrokstation, CAM software and CNC machine tool with control unit, the student will be able to initiate the control menu.

33. Provided wtih a CAD workstation, CAM software and CNC machine tool with control unit, the student will be able to run the CNC program on the machine tool.

34. Provided with a CAD workstation, CAM software and CNC machine tool with control unit, the student will be able to release all power the CNC machine tool.

35. Provided with a CAD workstation, CAM software and CNC machine tool with control unit, the student will be able to exit the control menu.

36. Provided with a CAD workstation, CAM software and CNC machine tool with control unit, the student will be able to exit the CNC editor software.

37. Provided with a CAD workstation, CAM software, CNC machine tool, and the appropriate wrenches and measuring devices, the student will be able to shut down the CNC mill, remove the workpiece from the machine, and inspect the part for correctness.

VIII.Unit Title: Fabrication Processes (Fastening Techniques)

1. Given a lecture on bonding, students will identify adhesive bonding with at least 90% accuracy.

2. Given a discussion on adhesives, students will list 7 advantages and 1 disadvantage of adhesives with 90% accuracy.

3. Given a lecture on bonding, students will identify 4 advantages respectively of epoxies, acrylics, and polyesters as bonding agents with at least 90% accuracy.

4. Given a lecture on bonding, students will identify cohesive bonding with at least 90% accuracy.

5. Given a demonstration applying adhesives, students will prepare a composites on surface for adhesives by

sanding/ solvent wiping with at least 90% accuracy.

6. Given a demonstration on bonding composites, students will bond composites with adhesives so no spots or only one small one is missed.

7. Given a demonstration on bonding advanced materials, students will bond advanced materials so no spots or perhaps only one small one is missed with an adhesive.

8. Given a demonstration on cohesive bonding of advanced materials, student will weld advanced materials (aluminum alloys) with 90% accuracy, i.e., a well-shaped bead that has good penetration.

9. Given a discussion/illustration on the strengthes/ weaknesses of adhesives and mechanical fasteners, students will compare/contrast 5 properties of adhesives with the same properties of mechanical fasteners with at least 80% accuracy.

10. Given a discussion on fastening with adhesives and mechanical fasteners, students will identify the advantages of using mechanical fasteners and adhesives in conjunction with each other with at least 90% accuracy.

11. Given a discussion on mechanical fasteners, students will list 6 mechanical fasteners with at least 90% accuracy.

12. Given a demonstration on mechanical fastening, students will fasten composites with 6 types of mechanical fasteners with at least 90% success.

13. Given a discussion/illustration on joint design, students will identify 14 joint designs with 90% success.

14. Given a demonstration in joint fabrication of composites, students will fabricate 5 types of composite/advanced material joints with at least 90% accuracy.

15. Given a discussion on joint design, students will identify 4 types of joint stress with at least 90% accuracy.

16. Given a discussion on joint design, students will identify the 2 best joints to use with respect to stress with at least 90% accuracy.

17. Given a discussion on composite structural joints, students will list 5 types of structural joints with at

least 90% accuracy.

18. Given a demonstration on fabricating structural joints, students will cut, assemble, and fasten 2 structural joints with at least 90% accuracy.

IX. Unit Title: Finishing Operations

1. Given a discussion on composites/advanced materials finishes, students will list 5 types of finishes for composites/advanced materials with at least 90% accuracy.

2. Given a demonstration in surface preparation of composites/ advanced materials, students will list 3 steps in their surface preparation with at least 90% accuracy.

3. Given a demonstration on finishing advanced materials/ composites, students will identify the need to follor the manufacturer's recommendations for surface preparation and applying finish with at least 90% accuracy.

4. Given a demonstration in surface preparation of composites/ advanced materials, students will solvent wipe, sand, or sand blast to prepare a surface for a finish, so that the finish properly adheres to the surface.

5. Given a demonstration on finishing composites/advanced materials, students will successfully apply a finish to composites/advanced materials so all areas are covered.

X. Unit Title: "Other" Technical Occupations in the Composite Materials Industry.

1. Given a lecture/discussion on technical occupations in composite materials industry, students will identify 4 of them with at least 80% accuracy.

2. Given field trip to a composite materials factory students will orally note and discuss two jobs in that factory that they are interested in obtaining.

SECTION V-c - MAJOR INSTRUCTIONAL UNITS

MAJOR INSTRUCTIONAL UNITS

INSTRUCTIONAL UNIT		Estimated Hours of Instruction
I	Introduction to Advanced Materials	30 hrs
II	Characteristics of Composite Materials	30 hrs
III	Design considerations: Processing Composites Materials	30 hrs
IV	Design and Drafting: CAD Utilization	60 hrs
V	Safety	30 hrs
VI	Machine Processes	60 hrs
VII	Integrating CAD/CAM with Advanced Materials Machining and Fabricating Processes	60 hrs
VIII	Fabrication Processes (Fastening Techniques)	60 hrs
IX	Finishing Operations	30 hrs
X	"Other" Technical Occupations in the Composites Industry	30 hrs

BEAVTS COURSE CONTENT LEVEL:I

PROGRAM:Metal Technology and Advanced Material Technology

MAJOR UNITS:1-CAD

CLASS HOURS:2

COMPETENCIES:
1. Define CAD, CAM, CIM
2. Name the two main parts of a CAD system
3. Name the five basic hardware components
4. Identify the CPU, and the input, display, storage, and output devices.
5. Turn on computer and start CAD software
6. Define the term "window"
7. Identify the drawing window
8. Identify the menu window
9. Identify the status window
10. Identify the cursor tracking window
11. Identify the history line and define its purpose
12. Identify the prompt line
13. Explain the menu tree structure
14. Define the positive axes for view coordinates
15. Define: grid, snap, cursor tracking, redraw, delete, undelete, and autoscale.
16. Demonstrate the immediate mode commands for the items defined above.

PERFORMANCE OBJECTIVES:
1. After reading about and discussing the terms CAD, CAM, CIM, the student will be able to define these terms.
2. After reading about and discussing the two main parts of a CAD system, the student will be able to list the two main parts of a CAD system.
3. After reading about and discussing the five basic hardware components, the student will be able to list the components.
4. After reading about and discussing the CPU, and the input, display, storage, and output devices, the student will be able to identify them.
5. After a demonstration by the instructor, the student will be able to turn on the computer and initiate the CAD software.
6. After reading about and discussing the term "window", the student will be able to define the term.

7-12. After reading about and discussing the window areas on the CAD screen display, the student will be able to identify the following window areas: drawing window, menu window, status window, cursor tracking window, history line, and prompt line.

13. After reading about and discussing the menu tree structure, the student will be able to describe the menu tree structure.
14. After reading about and discussing the positive axes for view coordinates, the student will be able to sketch the positive axes for view coordinates.

15. After reading about and discussing these terms, the student will be able to define: grid, snap, cursor tracking, redraw, delete, undelete, and autoscale.

. Provided with a CAD workstation, the student will be able to demonstrate the immediate mode commands for grid on/off, snap on/off, cursor tracking on/off, single delete, recall last, and autoscale zoom.

LEARNING ACTIVITIES:
Lesson on Chapters 1, 2, and 3 of Using Cadkey

TEACHING AIDS:
Text chapters
Overhead projector
Fig. 2-1
Fig. 3-1
Fig. 3-2
Fig. 3-3
Fig. 3-5
Video projector for CAD screen
CAD workstation

EVALUATION METHOD:
Written or oral quiz

BEAVTS COURSE CONTENT LEVEL:I

PROGRAM:Metal Technology and Advanced Material Technology

AJOR UNITS:2-CAD

CLASS HOURS:8

COMPETENCIES:

1. Define entity types used in CAD
2. Create lines with endpoints, string, and parallel options using cursor, end entity, intersection, & along line positioning
3. Demonstrate setting line types
4. Create rectangle and change scale of display and positon of center of display
5. Create points using polar and delta positioning
6. Create circles using all options on circle menu
7. Demonstrate appropriate use of all options in display menu
8. Create arcs using all options in arc menu
9. Create fillets and chamfers
10. Create horizontal and vertical lines
11. Create parallel and perpendicular lines
12. Create lines tangent to circles and arcs
13. Create lines at an angle to a reference line
14. Create 2D cubic open and closed splines

ERFORMANCE OBJECTIVES:

After reading about and discussing entity types used in CAD, the student will be able to list and describe the entity types.

2. Provided with a CAD workstation, the student will be able to create lines with endpoints, string, and parallel options using cursor, end entity, intersection, & along line positioning while creating a new CAD drawing or modifying an existing CAD drawing.
3. Provided with a CAD workstation, the student will be able to demonstrate setting line types while creating a new CAD drawing or modifying an existing CAD drawing.
4. Provided with a CAD workstation, the student will be able to create a rectangle and change the scale of the display and the positon of center of display while creating a new CAD drawing or modifying an existing CAD drawing.
5. Provided with a CAD workstation, the student will be able to create points using polar and delta positioning while creating a new CAD drawing or modifying an existing CAD drawing.
6. Provided with a CAD workstation, the student will be able to create circles using all options on circle menu while creating a new CAD drawing or modifying an existing CAD drawing.
7. Provided with a CAD workstation, the student will be able to demonstrate appropriate use of all options in display menu while creating a new CAD drawing or modifying an existing CAD drawing.
8. Provided with a CAD workstation, the student will be able to create arcs using all options in arc menu while creating a new CAD drawing or modifying an existing CAD drawing.

9. Provided with a CAD workstation, the student will be able to create fillets and chamfers while creating a new CAD drawing or modifying an existing CAD drawing.

Provided with a CAD workstation, the student will be able to create horizontal and vertical lines while creating a new CAD drawing or modifying an existing CAD drawing.

11. Provided with a CAD workstation, the student will be able to create parallel and perpendicular lines while creating a new CAD drawing or modifying an existing CAD drawing.
12. Provided with a CAD workstation, the student will be able to create lines tangent to circles and arcs while creating a new CAD drawing or modifying an existing CAD drawing.
13. Provided with a CAD workstation, the student will be able to create lines at an angle to a reference line while creating a new CAD drawing or modifying an existing CAD drawing.
14. Provided with a CAD workstation, the student will be able to create 2D cubic open and closed splines while creating a new CAD drawing or modifying an existing CAD drawing.

LEARNING ACTIVITIES:
Lessons on chapters 1-3 of Exploring Cadkey
Exercises at end of chapters 1-3.

TEACHING AIDS:
Text chapters
Video projector for CAD screen
CAD workstations

ALUATION METHOD:
CAD exercises and assignments

BEAVTS COURSE CONTENT LEVEL:I

PROGRAM:Metal Technology and Advanced Material Technology

MAJOR UNITS:3-CAD

CLASS HOURS:10

COMPETENCIES:

1. Demonstrate deleting entities from a drawing using the selection menu options single, chain, window, group,and all display
2. Demonstrate trimming and extending lines, arcs, and circles
3. Demonstrate correcting, altering, adjusting, and repositioning entities using the edit menu
4. Demonstrate breaking entities
5. Demonstrate recalling previously deleted entities
6. Demonstrate moving entities with the box move option
7. Demonstrate grouping options (make, add to, degroup, delete, list)
8. Demonstrate creating points along a line, arc, or circle
9. Demonstrate setting all line types and changing line types of entities
10. Demonstrate changing all line widths and changing line widths of entities
11. Demonstrate setting pen# and changing pen# of entities

PERFORMANCE OBJECTIVES:

1. Provided with a CAD workstation, the student will be able to demonstrate deleting entities from a drawing using the selection menu options single, chain, window, group,and all display while creating a new CAD drawing or modifying an existing CAD drawing.
2. Provided with a CAD workstation, the student will be able to demonstrate trimming and extending lines, arcs, and circles while creating a new CAD drawing or modifying an existing CAD drawing.
3. Provided with a CAD workstation, the student will be able to demonstrate correcting, altering, adjusting, and repositioning entities using the edit menu while creating a new CAD drawing or modifying an existing CAD drawing.
4. Provided with a CAD workstation, the student will be able to demonstrate breaking entities while creating a new CAD drawing or modifying an existing CAD drawing.
5. Provided with a CAD workstation, the student will be able to demonstrate recalling previously deleted entities while creating a new CAD drawing or modifying an existing CAD drawing.
6. Provided with a CAD workstation, the student will be able to demonstrate moving entities with the box move option while creating a new CAD drawing or modifying an existing CAD drawing.
7. Provided with a CAD workstation, the student will be able to demonstrate grouping options (make, add to, degroup, delete, list) while creating a new CAD drawing or modifying an existing CAD drawing.
8. Provided with a CAD workstation, the student will be able to demonstrate creating points along a line, arc, or circle while creating a new CAD drawing or modifying an existing CAD drawing.

9. Provided with a CAD workstation, the student will be able to demonstrate setting all line types and changing line types of entities while creating a new CAD drawing or modifying an existing CAD drawing.
0. Provided with a CAD workstation, the student will be able to demonstrate changing line widths and changing line widths of entities while creating a new CAD drawing or modifying an existing CAD drawing.
11. Provided with a CAD workstation, the student will be able to demonstrate setting pen# and changing pen# of entities while creating a new CAD drawing or modifying an existing CAD drawing.

LEARNING ACTIVITIES:
Lessons on chapter 4 of Exploring Cadkey
Exercises at end of chapter 4

TEACHING AIDS:
Text chapter
Video projector for CAD screen
CAD workstations

EVALUATION METHOD:
CAD exercises and assignments

BEAVTS COURSE CONTENT LEVEL:I

PROGRAM:Metal Technology and Advanced Material Technology

[illegible]JOR UNITS:4-CAD

CLASS HOURS:10

COMPETENCIES:
1. Demonstrate making levels active and inactive
2. Demonstrate making levels visible and invisible
3. Demonstrate moving entities to different levels
4. Demonstrate listing levels
5. Demonstrate turning grid and snap on and off
6. Demonstrate setting grid and snap X and Y values
7. Demonstrate aligning grid and/or snap to an entity
8. Demonstrate accessing the teach system
9. Demonstrate saving, loading and listing drawing part files
10. Demonstrate creating, retrieving and listing pattern files
11. Demonstrate saving and loading drawings as DXF files
12. Demonstrate saving plot files
13. Demonstrate plotting of a drawing both on-line and via plot files
14. Demonstrate using a printer to produce a hardcopy of a drawing

PERFORMANCE OBJECTIVES:
1. Provided with a CAD workstation, the student will be able to demonstrate making levels active and inactive while creating a new CAD drawing or modifying an existing CAD drawing.
2. Provided with a CAD workstation, the student will be able to demonstrate making levels visible and invisible while creating a new CAD drawing or modifying an existing CAD drawing.
3. Provided with a CAD workstation, the student will be able to demonstrate moving entities to different levels while creating a new CAD drawing or modifying an existing CAD drawing.
4. Provided with a CAD workstation, the student will be able to demonstrate listing levels while creating a new CAD drawing or modifying an existing CAD drawing.
5. Provided with a CAD workstation, the student will be able to demonstrate turning grid and snap on and off while creating a new CAD drawing or modifying an existing CAD drawing.
6. Provided with a CAD workstation, the student will be able to demonstrate setting grid and snap X and Y values while creating a new CAD drawing or modifying an existing CAD drawing.
7. Provided with a CAD workstation, the student will be able to demonstrate aligning grid and/or snap to an entity while creating a new CAD drawing or modifying an existing CAD drawing.
8. Provided with a CAD workstaion, the student will be able to demonstrate accessing the teach system while creating a new CAD drawing or modifying an existing CAD drawing.
9. Provided with a CAD workstation, the student will be able to demonstrate saving, loading and listing drawing part files while creating a new CAD drawing or modifying an existing CAD drawing.

10. Provided with a CAD workstation, the student will be able to demonstrate creating, retrieving and listing pattern files while creating a new CAD drawing or modifying an existing CAD drawing.
[illegible]. Provided with a CAD workstation, the student will be able to demonstrate saving and loading drawings as DXF files while creating a new CAD drawing or modifying an existing CAD drawing.
12. Provided with a CAD workstation, the student will be able to demonstrate saving plot files while crating a new CAD drawing or modifying an existing CAD drawing.
13. Provided with a CAD workstation, the student will be able to demonstrate plotting of a drawing both on-line and via plot files while creating a new CAD or modifying an existing CAD drawing.
14. Provided with a CAD workstation, the student will be able to demonstrate using a printer to produce a hardcopy of a drawing while creating a new CAD drawing or modifying an existing CAD drawing.

LEARNING ACTIVITIES:
Lessons on chapter 5 of Exploring Cadkey
Exercises at end of chapter 5

TEACHING AIDS:
Text chapter
Video projector for CAD screen
CAD workstations

EVALUATION METHOD:
CAD exercises and assignments

BEAVTS COURSE CONTENT LEVEL:I

PROGRAM:Metal Technology and Advanced Material Technology

MAJOR UNITS:5-CAD

CLASS HOURS:10

COMPETENCIES:
1. Properly dimension a detail drawing
2. Demonstrate the use of notes and labels on a drawing
3. Demonstrate setting units, tolerances, and number of decimal places for dimensioning
4. Demonstrate editing notes, labels, and dimensions
5. Demonstrate changing characteristics of dimensions, notes, and labels using the update option
6. Demonstrate verifying the attributes of an entity
7. Demonstrate verifying the coordinates of an entity
8. Demonstrate verifying the distances between two positions, two lines, and a position and an entity
9. Verify an angle
10. Verify the area and centroid of an enclosed figure
11. Verify the polar moment of inertia of an enclosed area
12. Demonstrate crosshatching a section view of a drawing

PERFORMANCE OBJECTIVES:
1. Provided with a CAD workstation, the student will be able to properly dimension a new or existing CAD detail drawing.
2. Provided with a CAD workstation, the student will be able to demonstrate the use of notes and labels on a new or existing CAD drawing.
3. Provided with a CAD workstation, the student will be able to demonstrate setting units, tolerances, and number of decimal places for dimensioning while creating a new CAD drawing or modifying an existing CAD drawing.
4. Provided with a CAD workstation, the student will be able to demonstrate editing notes, labels, and dimensions while creating a new CAD drawing or modifying an existing CAD drawing.
5. Provided with a CAD workstation, the student will be able to demonstrate changing characteristics of dimensions, notes, and labels using the update option while creating a new CAD drawing or modifying an existing CAD drawing.
6. Provided with a CAD workstation, the student will be able to demonstrate verifying the attributes of an entity while creating a new CAD drawing or modifying an existing CAD drawing.
7. Provided with a CAD workstation, the student will be able to demonstrate verifying the coordinates of an entity while creating a new CAD drawing or modifying an existing CAD drawing.
8. Provided with a CAD workstation, the student will be able to demonstrate verifying the distances between two positions, two lines, and a position and an entity while creating a new CAD drawing or modifying an existing CAD drawing.

9. Provided with a CAD workstation, the student will be able to verify an angle while creating a new CAD drawing or modifying an existing CAD drawing.
[illegible]. Provided with a CAD workstation, the student will be able to verify the area and centroid of an enclosed figure while creating a new CAD drawing or modifying an existing CAD drawing.
11. Provided with a CAD workstation, the student will be able to verify the polar moment of inertia of an enclosed area while creating a new CAD drawing or modifying an existing CAD drawing.
12. Provided with a CAD workstation, the student will be able to demonstrate crosshatching a section view of a new or existing CAD drawing.

LEARNING ACTIVITIES:
Lesson on chapter 6 of Exploring Cadkey
Exercises at end of chapter 6

TEACHING AIDS:
Text chapter
Video projector for CAD screen
CAD workstations

EVALUATION METHOD:
CAD exercises and assignments

BEAVTS COURSE CONTENT LEVEL:I

PROGRAM:Metal Technology and Advanced Material Technology

AJOR UNITS:6-CAD

CLASS HOURS:10

COMPETENCIES:
1. Define the terms translate, rotate, scale, and mirror
2. Describe the differences between the move, copy, and join options
3. Demonstrate translating an entity using the trans-r and trans-a options with move, copy, and join
4. Demonstrate rotation of an entity using the 2D rotate option with move, copy and join
5. Demonstrate scaling using move, copy and join
6. Demonstrate mirroring using move, copy and join

PERFORMANCE OBJECTIVES:
1. After reading about and discussing the terms translate, rotate, scale, and mirror, the student will define these terms with 90% accuracy.
2. After reading and discussing the differences between the move, copy, and join options the student will describe the differences between these terms.
3. Provided with a CAD workstation, the student will be able to demonstrate translating an entity using the trans-r and trans-a options with move, copy, and join while creating a new CAD drawing or modifying an existing CAD drawing.
4. Provided with a CAD workstation, the student will be able to demonstrate rotation of an entity using the 2D rotate option with move, copy and join while creating a new CAD drawing or modifying an existing CAD drawing.
5. Provided with a CAD workstation, the student will be able to demonstrate scaling using move, copy and join while creating a new CAD drawing or modifying an existing CAD drawing.
6. Provided with a CAD workstation, the student will be able to demonstrate mirroring using move, copy and join while creating a new CAD drawing or modifying an existing CAD drawing.

LEARNING ACTIVITIES:

Lessons on chapter 7 of Exploring Cadkey
Exercises at end of chapter 7

TEACHING AIDS:

Text chapter
Video projector for CAD screen
CAD workstations

EVALUATION METHOD:

CAD exercises and assignments

BEAVTS COURSE CONTENT LEVEL:I

PROGRAM:Metal Technology and Advanced Material Technology

AJOR UNITS:7-CAD

CLASS HOURS:10

COMPETENCIES:

1. Define the term wireframe model
2. Demonstrate creating a 3D wireframe model of an object by extruding a two dimensional drawing
3. Demonstrate the use of pattern files to create a four view drawing
4. Demonstrate the use of deletion and editing functions to finalize the four view drawing
5. Demonstrate the use of 3D CAD capabilities to create an assembly drawing

PERFORMANCE OBJECTIVES:

1. After reading about and discussing the term wireframe model, the student will be able to define the term.
2. Provided with a CAD workstation, the student will be able to demonstrate creating a 3D wireframe model of an object by extruding a two dimensional drawing.
3. Provided with a CAD workstation, the student will be able to demonstrate the use of pattern files to create a four view CAD drawing.

Provided with a CAD workstation, the student will be able to demonstrate the use of deletion and editing functions to finalize the four view CAD drawing.

5. Provided with a CAD workstation, the student will be able to demonstrate the use of 3D CAD capabilities to create an assembly drawing.

LEARNING ACTIVITIES:

Lessons on chapter 8 of Exploring Cadkey
Exercises at end of chapter 8

TEACHING AIDS:

Text chapter
Video projector for CAD screen
CAD workstations

EVALUATION METHOD:

CAD exercises and assignments

Unit V - Safety

Class Hours - 6

A. Chemical hazards

Discuss and list the following hazards at the blackboard:

1. Liquids
2. Mists
3. Vapors
4. Gases
5. Dusts
6. Carcinogenic (Cancer causing).

Read Chapter 3 of Industrial Plastics.

Evaluation: Unit Test

B. Possible effects of chemical hazards

Use the chalkboard to list and discuss the effects of chemical hazards:

1. Skin irritation
2. Blindness or damaged eyesight
3. Poisoning of liver, kidneys, and nervous system
4. Toxicity
5. Cancer.

Evaluation: Unit Test

C. Physical hazards

Discuss the following at the chalkboard:

1. Noise
2. Vibration
3. Improper use of machines
4. Various types of radiation
5. Using machines without guards.

Evaluation: Unit Test

D. Biological Accidents

Discuss these causes of biological accidents:

1. Poor machine design

2. Lack of ventilation.

See page 47 of Industrial Plastics.

E. Non-toxicity of plastics

Discuss the following characteristics of composites/ plastics:

1. Completely reacted plastics are non-toxic

2. Some are even planted in human bodies (show pictures of surgical implants).

Evaluation: Unit Test

F. Specific health hazards of monomers and plastics ingredients

See table on page 48 of Industrial Plastics to examine the health hazards of composites processing and other materials. Look at:

1. Acetone

2. Bisphenol A

3. Methylene Chloride

4. Toluene.

Evaluation: Unit Test

G. Proper storage of chemicals

Discuss and list on the chalkboard the following:

1. Storage temperature

2. Fire proof containers

3. Separate storage.

Evaluation: Unit Test

H. Fire toxicity of plastics

Discuss and list on the chalkboard the following:

1. Fumes

2. Smoke

3. Gases

Evaluation: Unit Test

I. Proper mixing of promoters and catalysts

Demonstrate the following:

1. Mix promoter to resin
2. Add catalyst
3. Warn of danger in mixing in any other order.

See page 49 of Industrial Plastics.

Provide student with job sheet for contact molding.

Mold skateboards using fiberglass/other reinforcements and polyester or epoxy resins.

See page 326 of Industrial Plastics

Also see pages 268-271 of Manufacturing: A Basic Text for Industrial Arts.

Evaluate:

1. Safe mixing of promoters and catalysts
2. Project design and fabrication.

J. Explosiveness of plastics dust

Examine the chart listing plastics dust explosiveness (those used in composites). See epoxies, page 590 of Industrial Plastics.

K. Factory safety factors to combat dust

Discuss and list on the chalkboard the following:

1. The need for dust collectors
2. Water cooling as a way to diminish dust
3. The need for proper light covers
4. The need for a proper mechanical ventilation system

Evaluation: Unit Test

L. Protective clothing

Discuss and list on the chalk board the following:

1. Goggles
2. Masks
3. Helmets
4. Hearing protectors

5. Air respirators

6. Gloves

Evaluation: Unit Test

M. Fire prevention

Use the chalkboard and an overhead transparency to discuss the following:

1. No sparks near composites dust, chemicals and certain metals

2. The use of flame-retardant additives

3. Note the proper class of fire extinguishers to use for materials and metals.

Evaluation: Unit Test

N. Equipment accident prevention

Use posters and the chalkboard to discuss the following:

1. Two-hand controls

2. Guards

3. Good housekeeping

4. Knowledge of materials and processes

5. Proper maintenance

6. Planned safety

Evaluation: Unit Test

O. Individual machine safety

Demonstrate/lecture on machine safety at each piece of equipment used in machining composites/advanced materials

1. Handtools

2. Portable power tools (routers, drills, saws)

3. Circular saws

4. Band saws

5. Drill presses

6. Grinders

7. Milling machines

8. Stamping, blanking and die cutting machines (lecture on them if they are not available)

9. Laser cutting (lecture on it if it is not available)

10. Hydrodynamic cutters.

Evaluation: Safety Tests on each machine

P. OSHA

Discuss and list on the blackboard the following:

1. The meaning of OSHA
2. The job of OSHA

Evaluation: Unit Test

Unit VI - Machine Processes

Class Hours - 15

A. Similarities in machining composites and wood/metal

Discuss and compare:

1. Machining composites and wood/metal
2. Machining thermoplastics and thermosetting plastics

Read Chapter 9

Evaluation: Unit Test

B. Decimal mathematics

Demonstrate the following at the board:

1. Adding decimals
2. Subtracting decimals
3. Multiplying decimals
4. Dividing decimals

Provide students with worksheets for the above math operations.

Evaluation: Quiz

C. Reading measuring instruments

Demonstrate and lecture using the chalkboard and posters/transparencies for the following:

1. Reading the vernier caliper
2. Reading a micrometer

Activity: Students must measure various job sheet samples

Evaluation: Measure 10 samples with each instrument

Evaluation: All projects must meet accuracy requirements

D. Blueprint reading

Using the chalkboard and transparencies discuss the following:

1. Identifying shapes
2. Hidden lines
3. Centerlines
4. Section drawings
5. Auxiliary views
6. Isometric views
7. Dimensions
    a. Size and contour
    b. Hole
    c. Location
    d. Datum line
    e. Tolerances

Evaluation: Provide measurements on 2 mechanical drawing reading tests.

E. Blade and bit materials

Using samples, discuss the following:

1. H.S.S. for twist drills
2. Cobalt for twist drills (for high production)
3. Carbide-coated masonry blades (for on-site cutting)
4. Carbide machine blades & bits
5. Diamond coated machine blades and bits

See pages 7-10 in Creative Pultrusion's Design Guide

Evaluation: Unit Test

F. Cooling agents for cutting composites

Discuss, demonstrate, and list on the chalkboard the following:

1. Liquids (water)
2. Air
3. Their 4 benefits

Evaluation: Unit Test

G. Rake angles for plastics/composites cutting tools

Demonstrate/discuss grinding composites/plastics rake angles for:

1. Twist drills (zero rake for plastics)
2. Circular saw blades (zero rake for plastics; however, they are not recommended for composites)
3. Note that regular rake angles may be used for composites and that most blades for composites lack traditional type teeth.

See pages 266 and 269 of Industrial Plastics

Evaluation: Grinding a zero rake angle for plastics cutting.

H. - Set for composites blades

Discuss/show set on the following blades at the blackboard

1. Zero set on masonry abrasive blades
2. 1/16" overall set on diamond coated blades (the difference between the thickness diamond coated part and the regular thickness of the blade)
3. Set on carbide-toothed blades for plastics (not recommended, but all right in emergencies for composites).

See page 266 of Industrial Plastics

Show actual blades during discussion

Evaluation: Unit Test

I. The proper number of saw teeth for composites/plastics cutting with the circular saw and bandsaw

Discuss and list at the chalkboard the following:

1. Lack of teeth (no teeth) on production abrasive or diamond-tipped blades
2. Less than four teeth per centimeter for thick plastics
3. Four or more teeth per centimeter for thin plastics
4. See chart in table 9-1, page 267 of Industrial Plastics

for the number of bandsaw teeth per centimeter for plastics.

See page 266 of Industrial Plastics and page 7-10 of Creative Pultrusions Design Guide

Evaluation: Unit Test

J. Bandsaw blade types

Discuss and portray the best type of bandsaw blades to use on composites:

1. Diamond (preferred)
2. Regular tooth (metal cutting is also okay with 11 tpi)

Evaluation: Unit Test

K. Drilling of composites: Special considerations

Discuss and demonstrate the following:

1. The amount of oversizing needed for twist drills (also note the need for oversizing punches)
2. Regulate speed for hole size
3. Use of bushings for drilling
4. Use of lubricants

See page 7-11 of Creative Pultrusion's Design Guide and pages 268-269 of Industrial Plastics

Evaluation: Hole size and hole smoothness in projects

L. Machine speed and feeding techniques for pultruded composites

Discuss and demonstrate proper speeds and feeding techniques on each machine listed below:

1. Circular saw (see table 9-1, page 267 in Industrial Plastics).
2. Radial arm saw
3. Band saw (see table 9-1, page 267 in industrial plastics)
4. Router
5. Drill press and portable power drill (see table 9-3, page 269, and table 9-4, page 270 in Industrial Plastics)

Also note the following tips:

6. Slow the speed in fraying develops

7. Use slower feeds on thick materials

8. The recommended cutting speed is 1750 RPM.

See page 7-10 of Creative Pultrusions Design Guide.

Activity: students will employ proper speeds/feeds while manufacturing their skateboards (see section I, Unit IV), clip boards (see section E, Unit III) and other projects.

Evaluation: Check project edges for fraying or burning.

M. Other machining considerations

Discuss and demonstrate the following:

1. Adequately clamp materials and provide internal solid supports for thin, hollow materials

(See pages 7-1, 7-3, and 7-11 of Creative Pultrusions Design Guide.)

2. Cut veiled-surface materials with the "seen or exposed side" up

(See page 7-10 of Creative Pultrusions Design Guide.)

3. Precision cutting is obtained by clamping on both sides of a cut and by making "second" cuts

(See page 7-9 and 7-10 of Creative Pultrusions Design Guide.)

4. In general minimum tolerances will be ± 1/16" for heavy production

5. Air power is preferred for routers and grinders

6. Avoid excess pressure while machining; tools dull more quickly.

Evaluation: Check structural joint projects for ± 1/16" accuracy. Also observe for correct machining techniques by students

N. Grinding

Discuss and demonstrate the following grinding techniques:

1. Use coarse or medium carbide wheels

2. Use sparingly; it is not usually recommended.

See page 7-11 of Creative Pultrusion's Design Guide

Evaluate projects for smooth edges and proper tool techniques

O. Punching operations

Discuss and list on the chalkboard the following:

1. Punch cutting-tip shear angle

(See page 7-17 of Creative Pultrusion's Design Guide.)

2. The need for oversized punches

3. Use of lubricants - silicones

(See page 7-14 of Creative Pultrusions Design Guide.)

4. Mat-reinforced fiberglass plastics have closer punch tolerance than roving frp

(See page 7-14 of Creative Pultrusions Design Guide.)

5. Large holes punch cleaner than small holes.

See page 7-17 of Creative Pultrusion's Design Guide.

Evaluation: Grade projects on punched-hole locations, taking into account that composites (frp) hole tolerances must sometimes be large.

P. Shearing operations

Discuss and list at the chalkboard the following:

1. Identifying shearing operations

2. Shearing perpendicular to the grain of composites.

See page 7-18 of Creative Pultrusion's Design Guide.

3. Evaluate students' knowledge of shearing on unit tests and projects, if shears are available

Q. Threading

Discuss and demonstrate the following:

1. The proper sequence of operations in lathe thread-cutting

2. Use of lubricants on plastics when using taps and dies

3. Removal of only 75% of threads when using taps and dies

4. Selection of proper thread forms.

See page 270 of Industrial Plastics

Evaluate threads cut for project bolts

Observe thread cutting techniques and correct as necessary

R. Jigs/Fixtures

Discuss and demonstrate the set up of the following

1. Jigs

2. Fixtures

3. Multiple blade set-up (Visit bedford reinforced plastics for an example.

See pp. 404-409 Manufacturing in a Basic Text for Industrial Arts.

Show jigs and fixtures on transparencies.

Evaluate accuracy of jigs and/or multiple blade set up

S. Climb cutting with the milling machine

Demonstrate and discuss the following with respect to climb cutting on the milling machine:

1. Discuss climb cutting principles - work goes in same direction as cutter

2. Climb cut alloys

3. Climb cut filled plastics.

See page 272 of Industrial Plastics.

Evaluate climb cut alloys and plastics

T. Unique cutting techniques

At the chalkboard discuss and define the following:

1. Laser cutting

2. Thermal cutting

3. Hydrodynamic cutting.

See pages 272, 273, and 274 of Industrial Plastics.

Note that laser cutting can be depth controlled, and that thermal cutting is good for cellular plastics (these materials could be contained in laminates).

Evaluation: Unit Test

COMPARISON OF ADHESIVES USED WITH PULTEX SHAPES

	Epoxies	Acrylics	Polyesters
Important Details:	Strongest average lap shear can be around 1200 psi. Adheres to many surfaces.	Lower Cost. Impurity tolerant.	•Easy to work with. •Bonds well with thermosets.
Substrates:	Many use clean surfaces	Metals, Glass, Plastics, Ceramics.	Metals and plastics.
Resistant to:	Moisture, acids, bases, salts,	Moisture, solvents acids.	Moisture, some acids.
Dispensing Methods:	Meter mixing Hand mixing	Meter mixing Hand mixing	Meter mixing Hand mixing
Strength:	Strongest up to 6000 psi Average 1200 psi	Strong up to 4000 psi Average 700 psi	Strength up to 2500 psi Average 500 psi
Cure time:	Wide range	Set: 8 minutes Cure: 24 hours	Cures quickly
Formulas available:	Thousands	Many	Many
Upper temperature range:	Wide range up to 500°	250° maximum	250° maximum
Cost relative to other adhesives:	Moderate	Moderate	Low

COMPARISON OF JOINING TECHNIQUES

	Mechanical	Adhesive Bonds
Seal (water tightness)	no	yes
Thermal insulation	no	yes
Electrical insulation	no	yes
Stress concentration at joint	high	medium
Strength/weight ratio	low	medium
Aesthetics (smooth joints)	bad	good
Fatigue endurance	bad	good
Inspection	easy	difficult
Skill required of fabricator	low	high
Sensitive to peel loading	no	yes
Time to develop strength	immediate	long
Disassembly	possible	impossible

Used with permission, from Creative Pultrusion's Design Guide, page 7-8.

UNIT VII - INTEGRATING CAD/CAM WITH ADVANCED MATERIALS MACHINING & FABRICATING PROCESSES

[illegible]MMARY OF UNITS 1-3 ON CAD/CAM:

The CAD/CAM curriculum additions are in three primary units. The first unit is an introduction to CAD/CAM and basic CNC programming. The second unit is the utilization of CAM software to interactively develop a CNC program utilizing an existing CAD DXF file. Finally, the third unit is the utilization of CAM software to run an existing CNC program. Due to the copyright laws and proprietary rights that cover the sale and use of CAD and CAM software and its manuals, it will be required that educators who want to utilize this curriculum purchase the software and manuals for a specific CAD/CAM application. An effort has been made to make this curriculum as "generic" as possible (but still remain useful) so that it can be used as a guide for use with any combination CAD/CAM software and CNC machine tool combination.

BEAVTS COURSE CONTENT LEVEL:I

PROGRAM:Metal Technology and Advanced Material Technology

MAJOR UNITS:1-CAD/CAM

CLASS HOURS:10

COMPETENCIES:
1. Define CAM
2. Define CNC
3. Identify Cartesian coordinate system
4. Identify coordinates of points in 2 dimensional coordinate system
5. Identify coordinates of points in 3 dimensional coordinate system
6. Define basic CNC commands (rapid, linear, clockwise, and counter-clockwise motions)
7. Define a block
8. Define G-codes
9. Define M-codes
10. Identify rapid, linear, clockwise, and counter-clockwise CNC commands
11. Be aware of and understand current general machine shop safety practices and procedures as well as current specific cautions and safety practices and procedures that apply to the specific CNC machine tool to be used by the instructor and student.

PERFORMANCE OBJECTIVES:

After reading about and discussing Computer-Aided-Manufacturing (CAM), the student will be able to define CAM.

2. After reading about and discussing Computer-Numerical-Control (CNC), the student will be able to define CNC.
3. After reading about and discussing Cartesian coordinate systems, the student will be able to identify a Cartesian coordinate system.
4. After reading about and discussing how to identify coordinates of a points in a 2 dimensional coordinate system, the student will be able to plot points, and determine coordinates of points.
5. After reading about and discussing how to identify coordinates of a points in a 3 dimensional coordinate system, the student will be able to plot points, and determine coordinates of points.
6. After reading about and discussing the basic CNC commands (rapid, linear, clockwise, and counter-clockwise motions), the student will be able to define these commands.
7. After reading about and discussing blocks, the student will be able to define the term.
8. After reading about and discussing G-codes, the student will be able to define G-codes.
9. After reading about and discussing M-codes, the student will be able to define basic M-codes, and identify them within a block.
10. After reading about and discussing rapid, linear, clockwise, and counter-clockwise CNC commands, the student will be able to identify these commands by their G-codes within a block.
11. After reading about and discussing general machine shop safety and specific safety practices and procedures for the CNC mill, the student will be able to operate the machine tool safely by following these safety guidelines.

LEARNING ACTIVITIES:

Lessons 3 and 4 from CAD/CAM instruction manual (or equivalent)
Review machine shop safety!

ACHING AIDS:

Copies of lessons from manual
Overhead projector
Machine shop safety handout

EVALUATION METHOD:

Written or oral quiz

BEAVTS COURSE CONTENT LEVEL:I

PROGRAM:Metal Technology and Advanced Material Technology

[illegible]OR UNITS:2-CAD/CAM

CLASS HOURS:10

COMPETENCIES:

1. Select and load appropriate cutting tool into machine
2. Align machine and tool to origin
3. Select and set proper spindle speed on machine tool
4. Initiate CAM software
5. Select appropriate CAD system for desired drawing
6. Load a DXF file onto system
7. Send generated CNC program to machine and disk
8. Utilize the CAM software to select tool diameter
9. Position tool in starting positon by aligning to CAD drawing
10. Demonstrate moving tool to enter work
11. Demonstrate defining cutting path utilizing the existing CAD geometry
12. Return tool to origin

PERFORMANCE OBJECTIVES:

1. Provided with a CNC mill, appropriate end mill, and appropriate wrenches, the student will be able to select and load appropriate cutting tool into machine.

[illegible] Provided with a 1/2" dowel pin and 3/8" alignment pin, the student will be able to align the CNC machine and tool to the origin designated by the instructor.

3. Provided with a CNC mill, the student will be able to select and set the proper spindle speed on the CNC machine tool.
4. Provided with a CAD workstation and CAM software, the student will be able to initiate CAM software.
5. Provided with a CAD workstation, CAM software, and the appropriate CAD drawing as a DXF file, the student will be able to select appropriate CAD system for desired drawing.
6. Provided with a CAD workstation, CAM software, and the appropriate CAD drawing as a DXF file, the student will be able to load a DXF file onto the CAM system.
7. Provided with a CAD workstation,CAM software and a CNC mill, the student will be able to send the generated CNC program to the CNC machine and save the CNC program on a diskette.
8. Provided with a CAD workstation, CAM software and a CNC mill, the student will be able to utilize the CAM software to select the appropriate tool diameter.
9. Provided with a CAD workstation, CAM software and a CNC mill, the student will be able to position the cutting tool in starting positon by aligning to the CAD drawing.
10. Provided with a CAD workstation, CAM software and a CNC mill, the student will be able to demonstrate moving the cutting tool to enter the workpiece.
11. Provided with a CAD workstation, CAM software and a CNC mill the student will be able to demonstrate defining the cutting path utilizing the existing CAD geometry.

12. Provided with a CAD workstation, CAM software and a CNC mill, the student will be able to return the cutting tool to back to the designated origin, shut down the CNC mill, and exit the CAM software.

ARNING ACTIVITIES:

Instructor's demonstration of setting up CNC machine tool with appropriate cutting tool, aligning tool to origin, selecting and setting cutting speed, and running CAM software. Emphasize safety!

TEACHING AIDS:

CAD workstation
CAM software
CNC machine tool
Appropriate cutting tools and wrenches
Plaque material

EVALUATION METHOD:

Visual observation of plaque project

BEAVTS COURSE CONTENT LEVEL:I

PROGRAM:Metal Technology and Advanced Material Technology

MAJOR UNITS:3-CAD/CAM

CLASS HOURS:40

COMPETENCIES:
1. Select and load appropriate cutting tool into machine
2. Align machine and tool to origin
3. Select and set proper spindle speed on machine tool
4. Initiate CNC editor software on computer
5. Load existing CNC program
6. List program to verify correctness
7. Initiate CNC machine control unit (MCU)
8. Transfer CNC program from computer to MCU
9. Initiate control menu
10. Run CNC program on machine tool
11. Release all power to CNC machine tool
12. Exit control menu
13. Exit CNC editor software
14. Remove workpiece from machine and inspect

PERFORMANCE OBJECTIVES:
1. Provided with a CNC mill, appropriate end mill, and appropriate wrenches, the student will be able to select and load appropriate cutting tool into machine.
2. Provided with a 1/2" dowel pin and 3/8" alignment pin, the student will be able to align the CNC machine and tool to the origin designated by the instructor.
3. Provided with a CNC mill, the student will be able to select and set the proper spindle speed on the CNC machine tool.
4. Provided with a CAD workstation and CAM software, the student will be able to initiate CNC editor software on computer.
5. Provided with a CAD workstation and CAM software, the student will be able to load an existing CNC program into the CNC editor.
6. Provided with a CAD workstation and CAM software, the student will be able to list the CNC program to verify the correctness of the loading procedure.
7. Provided with a CAD workstation, CAM software and CNC machine tool with control unit, the student will be able to initiate CNC machine control unit (MCU).
8. Provided with a CAD workstation, CAM software and CNC machine tool with control unit, the student will be able to transfer the CNC program from the computer to the MCU.
9. Provided with a CAD workstation, CAM software and CNC machine tool with control unit, the student will be able to initiate the control menu.
10. Provided with a CAD workstation, CAM software and CNC machine tool with control unit, the student will be able to run the CNC program on the machine tool.

11. Provided with a CAD workstation, CAM software and CNC machine tool with control unit, the student will be able to release all power to the CNC machine tool.

Provided with a CAD workstation, CAM software and CNC machine tool with control unit, the student will be able to exit the control menu.

13. Provided with a CAD workstation, CAM software and CNC machine tool with control unit, the student will be able to exit the CNC editor software.
14. Provided with a CAD workstation, CAM software, CNC machine tool, and the appropriate wrenches and measuring devices, the student will be able to shut down the CNC mill, remove the workpiece from the machine, and inspect the part for correctness.

LEARNING ACTIVITIES:

Instructor's demonstration of setting up CNC machine tool with appropriate cutting tool, aligning tool to origin, selecting and setting cutting speed, and running CAM software. Emphasize safety!

CNC machining project

TEACHING AIDS:

CAD workstation
CAM software
CNC machine tool
CNC program for project
Appropriate cutting tools and wrenches
Workpiece material

ALUATION METHOD:

Visual observation of machining and inspection process

COMPARISON OF ADHESIVES USED WITH PULTEX SHAPES

	Epoxies	Acrylics	Polyesters
Important Details:	Strongest average lap shear can be around 1200 psi. Adheres to many surfaces.	Lower Cost. Impurity tolerant.	•Easy to work with. •Bonds well with thermosets.
Substrates:	Many use clean surfaces	Metals, Glass, Plastics, Ceramics.	Metals and plastics.
Resistant to:	Moisture, acids, bases, salts,	Moisture, solvents acids.	Moisture, some acids.
Dispensing Methods:	Meter mixing Hand mixing	Meter mixing Hand mixing	Meter mixing Hand mixing
Strength:	Strongest up to 6000 psi Average 1200 psi	Strong up to 4000 psi Average 700 psi	Strength up to 2500 psi Average 500 psi
Cure time:	Wide range	Set: 8 minutes Cure: 24 hours	Cures quickly
Formulas available:	Thousands	Many	Many
Upper temperature range:	Wide range up to 500°	250° maximum	250° maximum
Cost relative to other adhesives:	Moderate	Moderate	Low

COMPARISON OF JOINING TECHNIQUES

	Mechanical	Adhesive Bonds
Seal (water tightness)	no	yes
Thermal insulation	no	yes
Electrical insulation	no	yes
Stress concentration at joint	high	medium
Strength/weight ratio	low	medium
Aesthetics (smooth joints)	bad	good
Fatigue endurance	bad	good
Inspection	easy	difficult
Skill required of fabricator	low	high
Sensitive to peel loading	no	yes
Time to develop strength	immediate	long
Disassembly	possible	impossible

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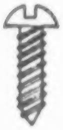
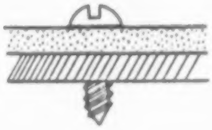
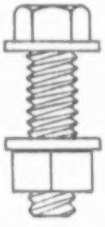
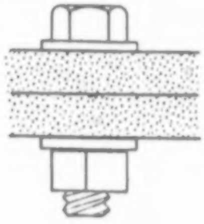
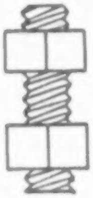
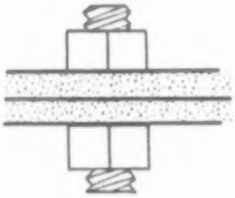
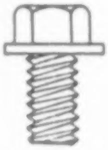
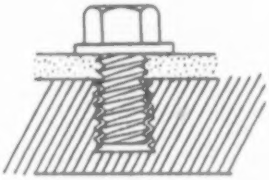
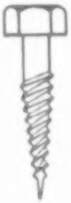
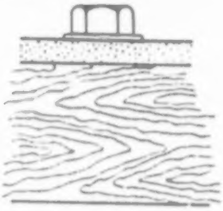
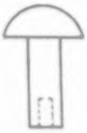
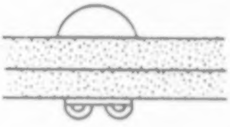
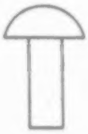
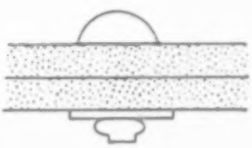
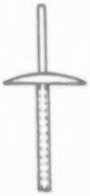
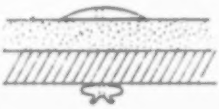
MECHANICAL

APPLICATION	FASTENER	ENGAGED
SCREW Used for fastening Pultex shapes to metal. Use metal as backup to fiberglass.		
BOLT AND NUT Used for fastening parts together. Best to use washers to distribute load whenever possible. Steel, galvanized, silicon bronze, nylon, polyester and other materials available for a wide range of applications. Check with your supplier.		
THREADED ROD AND NUT Threaded fiberglass rods with molded fiberglass nut. Good for high corrosion applications. Good shear values.		
BOLTS AND THREADED HOLE Possible assembly technique; however, special construction of Pultex part required. Fiberglass nuts above are made by this technique. Epoxies or other adhesives greatly improve joint strength.		
LAG SCREW Can be used to attach parts to wood. Washer should be used to distribute load. Not recommended for attaching fiberglass to fiberglass.		
TUBULAR RIVET Used in conjunction with washer or metal backup plate. Stronger than pop-rivets because of solid shank. Requires accessibility from both sides of part.		
SOLID RIVETS Use with backup plate or washer. Must have accessibility to both sides of work.		
BLIND RIVETS Pull-up mandrel. Special tool required. Assembly from one side only. Good for fiberglass to metal or can be used with washer backup. Steel or aluminum.		

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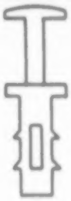
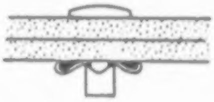
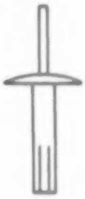
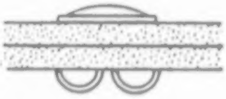
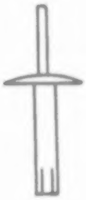
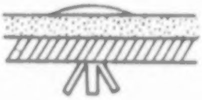
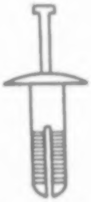
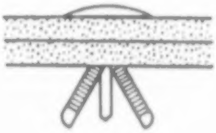
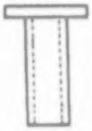
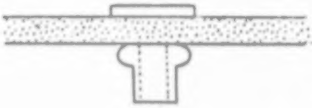
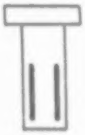
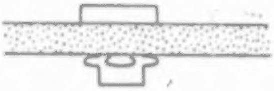
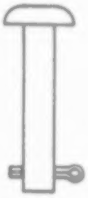
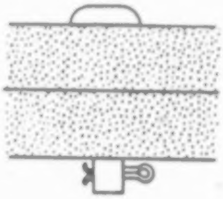
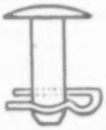
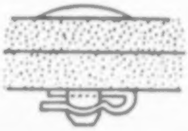
FASTENINGS

FASTENER	ENGAGED	APPLICATION
		**NYLON RIVET** Crimp type rivet. Requires special tool for installation. Good for mild corrosive environment insulating.
		**T RIVET** Good for metal to fiberglass or fiberglass to fiberglass with backup plate. Wide expansion gives good load distribution and prevents tear out. Aluminum.
		**DRIVE RIVET (Aluminum)** Good for fiberglass to metal. Can be installed with hammer. Can also be removed from one side by driving out mandrel.
		**DRIVE RIVET (Nylon)** Installed with hammer. Same as above. Lower shear value than metal. Center core stays in place.
		**BLIND THREAD INSERTS** Applies metal threads to part. Good for things where disassembly is required. Hexagon shape available to prevent twist. Special tool required.
		**BLIND THREAD INSERTS (Expand)** Better torque and shear strength. Loads more evenly spread on back surface.
		**CLEVIS AND PIN (Metal)** Can be used for same installations. Not very tight fit normally.
		**CLEVIS AND PIN (Nylon)** Used in some installations. Electrical insulating properties.

Used with permission, from Creative Pultrusion's Design Guide, page 7-23.

Unit VIII - Fabrication processes (fastening techniques)

Class Hours - 10

A. Bonding techniques

At the chalkboard discuss the following. Use transparencies to portray examples. Read Chapter 15 of Industrial Plastics.

1. Adhesive bonding
2. The advantages/disadvantages of adhesives (Read page 7-4, Creative Pultrusion's Design Guide).
3. The advantages respectively of epoxies, acrylics and polyester bonding agents (See chart from Creative Pultrusions Design Guide, page 7-8.)
4. Cohesive bonding

Evaluate on Unit Test

B. Demonstrating bonding techniques

Demonstrate/discuss the following:

1. Surface preparations by sanding/solvent wiping
2. Applying adhesives to composites.
3. Applying adhesives to aluminum alloys or other advanced materials

See p. 7-7 of Creative Pultrusion's Design Guide.

Evaluate adhesive application in terms of amount of adhesive used and competeness of coverage

C. Aluminum alloy welding

Demonstrate/discuss the following:

1. Cohesive bonding of aluminum alloys by welding
2. TIG welding set up and operation.

Evaluate bead contour and penetration

D. Mechanical Fasteners

At the chalkboard discuss the following:

1. The comparison of adhesive fastemers to mechanical fasteners
2. The fact that mechanical fasteners used in conjunction with adhesives normally provide the best application
3. Product environment must also be considered when

selecting fasteners

4. Six types of mechanical fasteners
    a. Screws and bolts and nuts
    b. Solid rivets
    c. Blind rivets
    d. Drive rivets
    e. Blind thread inserts
    f. Clevis and pin.

See page 7-3, 7-8, 7-22, and 7-23 of Creative Pultrusion's Design Guide

Provide student with information sheets comparing adhesives to mechanical fasteners and illustrating mechanical fasteners.

Evaluate on Unit Test

E. Applying mechanical fasteners

Demonstrate the application of the following mechanical fasteners:

1. Screws and bolts
2. Solid rivets
3. Blind rivets
4. Drive rivets
5. Blind thread inserts
6. Clevis and pin

Evaluate proper selection and use of fasteners on projects.

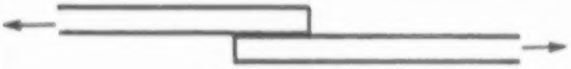
F. Joint Design

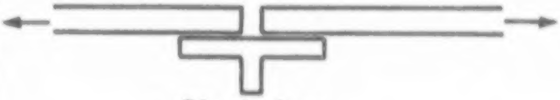
Discuss/illustrate the following types of joint designs.

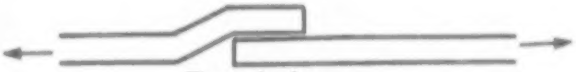
Provide students with information sheets on joint design.

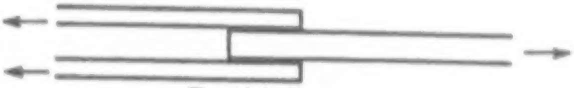
1. Single lap and variation
2. Toggle lap
3. Double lap and variations
4. Beveled double lap
5. Step lap

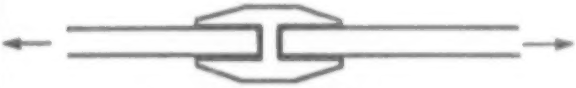
BONDED SHEAR JOINT CONCEPTS

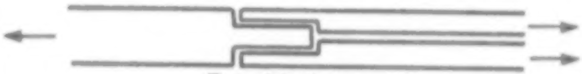

Single Lap

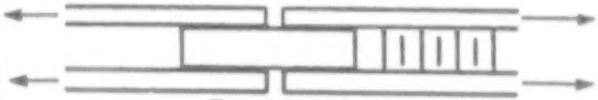

Single Lap

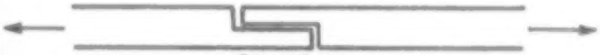

Toggle Lap

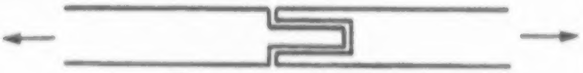

Double Lap

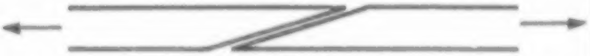

Beveled Double Lap

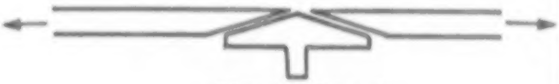

Double Lap

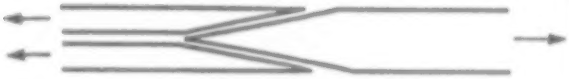

Double Lap

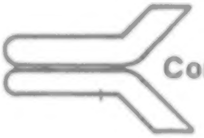

Step Lap

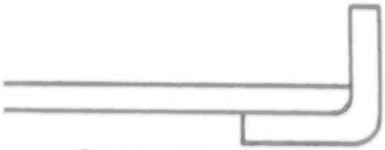

Tongue & Groove

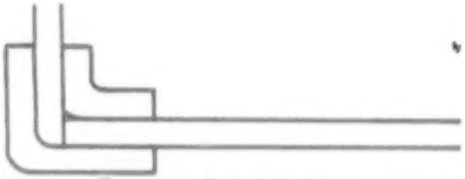

Simple Scarf


Simple Scarf


Double Scarf


Corner Single Lap


Corner Single Lap


Corner Double Lap

Used with permission, from Creative Pultrusion's Design Guide, page 7-5.

6. Tongue and groove

7. Simple scarf and variation

8. Double scarf

9. Corner single lap and variation

10. Corner double lap

See page 7-5 of Creative Pultrusion's Design Guide.

Evaluate on Unit Test

G. Fabricating a joint

Demonstrate/discuss the following:

1. The students fabrication of 5 joints in the completion of projects

2. Considering 4 types of joint stress when selecting joints

3. The best joints to use with respect to stress:

    a. Those involving direct tension

    b. Those involving direct shear

4. The actual cutting and fastening of a joint.

Use actual samples for points 2 and 3.

See page 7-6 of Creative Pultrusion's Design Guide.

Evaluate project in terms of proper joint selection. Also evaluate on unit test.

H. Composite structurals joints

Discuss the following structurals joints by using an overhead transparency:

1. Channel joints

2. Tube joints

3. Fabricated beams

4. I-beam joints

5. Platform supports.

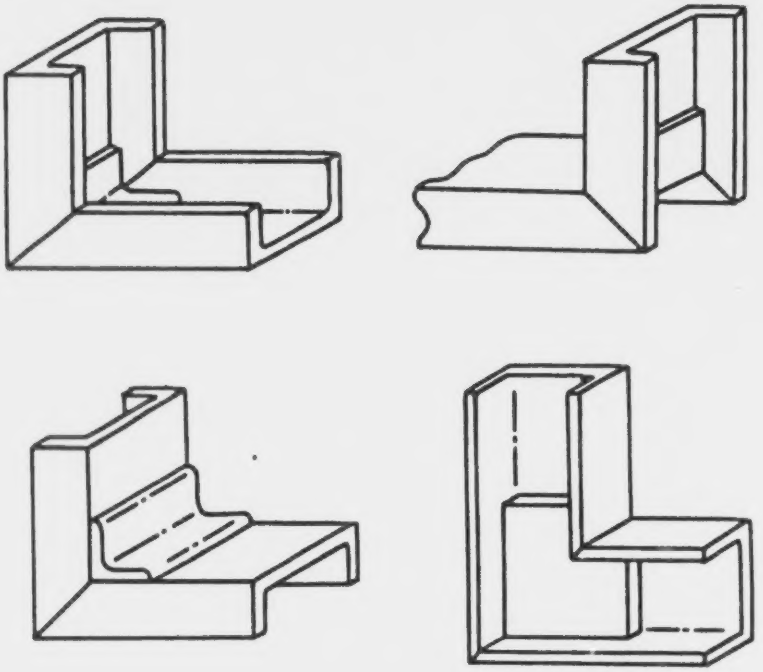
See pages 7-20 and 7-21 of Creative Pultrusions Design Guide

Evaluate on Unit Test

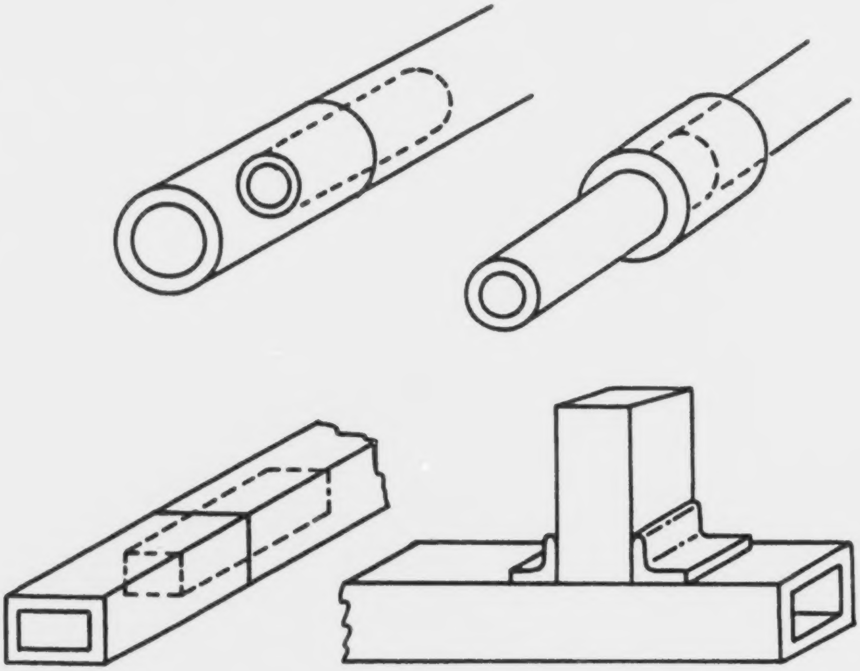
I. Fabricating structurals joints

JOINING STANDARD STRUCTURALS

Channel Joints



Tube Joints



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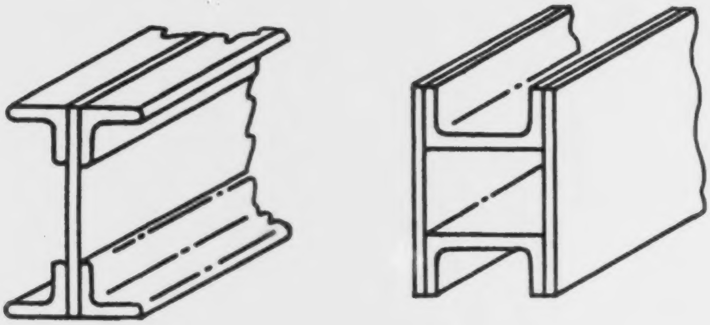
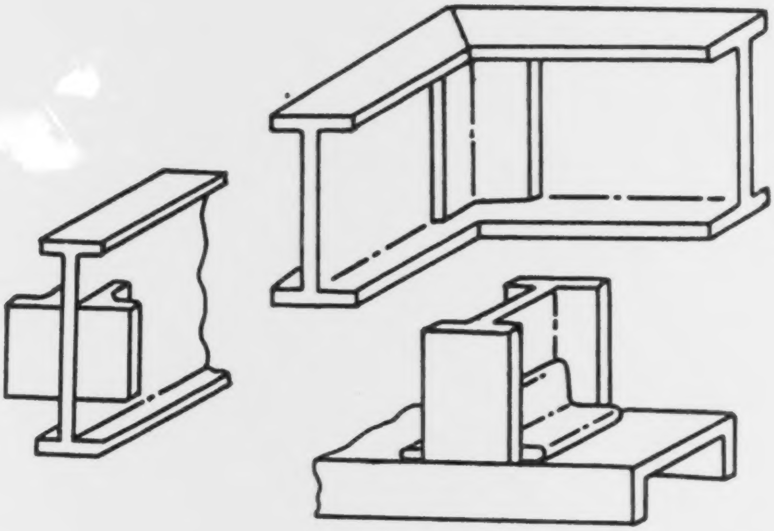
JOINING STANDARD STRUCTURALS

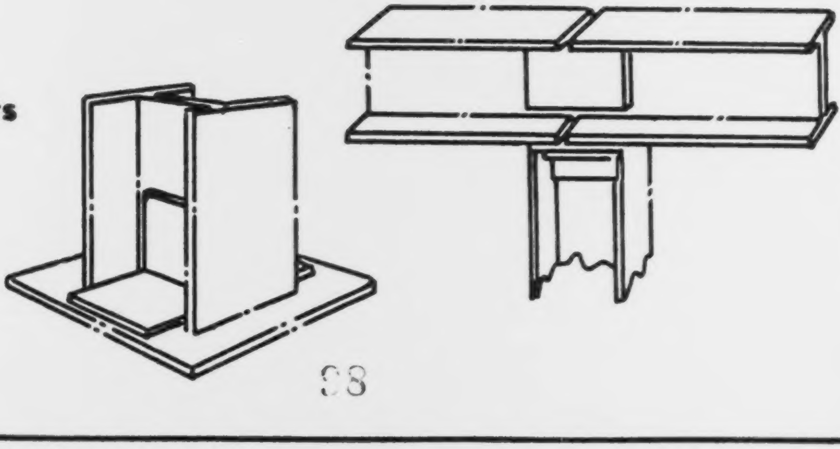
Fabricated Beams



I-Beam Joints



Platform Supports



Used with permission, from Creative Pultrusion's Design Guide, page 7-21

Demonstrate/discuss the fabrication of the following joints:

1. Channel joints
2. Tube joints
3. Fabricated beams
4. I-beam joints
5. Platform supports.

See pages 7-20 and 7-21 of Creative Pultrusion's Design Guide.

Evaluation: Examine structural joints in terms of accuracy, the proper joint for the application, and assembly with proper fasteners.

Unit IX - Finishing Operations

Class Hours - 5

A. Preparation for finishing

Discuss the following at the chalkboard:

1. Selecting a finish
    a. Internal coloring
    b. Urethane coatings
    c. Enamels
    d. Lacquers
    e. Electrostatic coatings
2. Steps in or types of surface preparation
    a. Follow manufacturer's recommendations
    b. Solvent wiping
    c. Sanding
    d. Sand blasting
    e. Use of sand and fill primers.

See page 7-19 of Creative Pultrusion's Design Guide

Evaluation: Unit Test

B. Actual Surface Preparation

Demonstrate/discuss the steps or types of surface preparation:

1. Check finish manufacturer's directions
2. Solvent wipe surface
3. Sand as necessary
4. Sand blast if desired
5. Use sand and fill primers as necessary

See page 7-19 of Creative Pultrusion's Design Guide

Evaluate in terms of finish obtained (smoothness, lack of scratches and adherence of finish)

C. Applying a finish

Demonstrate/Discuss the following:

1. Brush application
2. Spray application
3. Electrostatic coating

See page 7-19 of Creative Pultrusions Design Guide

If facilities/equipment do not permit electrostatic coating, illustrate the process with pictures.

Evaluate projects for smoothness of finish and completeness of surface coverage.

Unit IX - "Other Technical Occupations in the Composites Industry"

Class Hours - 4

A. Technical occupations in composites manufacturing

Discuss the following at the chalkboard:

1. Engineers
2. Chemists
3. Machinists - for mold making
4. Electroplating technicians - for mold chroming
5. Quality control personnel

See Chapter 3, Chapter 4 and page 6-1 of Creative Pultrusion's Design Guide

Students may research these occupations or others in the composites industry to realize where positions might exist, what salaries are and what duties are associated with each job.

Evaluate research project

B. Trip to composites factory

Discuss the following:

1. Engineering and product design
2. Pultrusion or other composites manufacturing processes
    a. Materials used
    b. Machines and blades
    c. Safety
3. Fabrication of products
4. Quality control

SECTION V-d - LEARNING ACTIVITIES

LEARNING ACTIVITIES

Unit I - Introduction to Composites/Advanced Materials

Class Hours - 4

A. Plastics as a Base for Composites

Introduce advanced and composite materials. Discuss plastics as the base material for many composites. Use chalkboard or easel to:

1. Define "Plastics"
2. Identify sources of "Plastics"
3. Define monomer and polymer
4. Differentiate thermoplastics from thermosetting plastics
5. Note the use of thermosetting plastics in composites
6. Identify the 3 basic, broad areas of the plastics industry

Read chapter 1 and pp. 30, 31, 35 and 36 in Industrial Plastics

Evaluation: Unit Test

B. Identification of Composites and Advanced Materials and their Applications.

Use chalkboard to discuss the following:

1. Define composite materials
2. Define fiberglass reinforced plastics (frp)
3. Show composite reinforcing materials-advanced materials
4. Identify aluminum alloys
5. Identify titanium
6. Identify thermoplastic fibers.
7. Show applications of composites/advanced materials

Read pp. 144-149 in Industrial Plastics

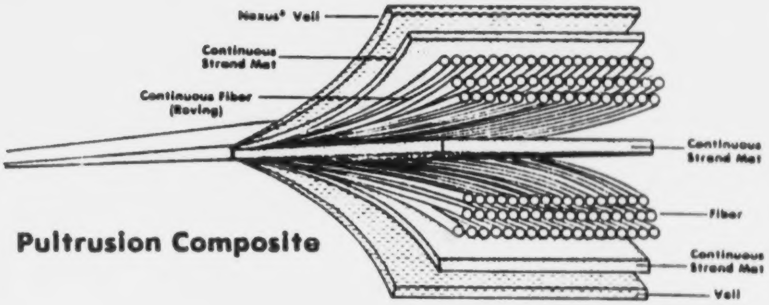
Provide students with samples of plastics, composites, and advanced materials.

Show pultruded composite overhead transparency.

Show applications of composites.

Show applications of advanced materials

Chapter 3 Design Capabilities



Pultrusion Composite

INTRODUCTION TO DESIGN CAPABILITIES

Pultrusions, which are a composite of several different materials and reinforcements, present the opportunity to to design parts with properties to meet specific needs. Fiber reinforcements and loadings can be varied to produce a wide range of strengths in the end product.

Typical structural items are 35% to 40% glass. This loading is usually split 50-50 between continuous roving and continuous strand mat. This type of composite is widely used in the pultrusions industry for determining the standard mechanical properties of pultruded structurals.

These properties, though widely used, are not the only properties obtainable. Tensile strengths, for example can vary from 6,000 psi to 145,000 psi, depending on the glass loading and resin selection. A good method for determination of physical properties is the **RULE OF MIXTURES:**

Rule of Mixtures

LONGITUDINAL: $X_c = V_r X_r + V_f X_f$

TRANSVERSE: $\frac{1}{X_c} = \frac{V_r}{X_r} + \frac{V_f}{X_f}$

x = desired properties
V_r = volume of resin in percentage
V_f = volume of fibers in percentage
X_f = properties of fibers
X_c = desired properties
X_r = properties of resin

This formula allows the designer to calculate a close approximation of the expected properties. However, there are two considerations when using this formula. The first is that the end composite must fall into a proper glass loading range. This range may vary from 18% to 75%. The second con-

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Activity: students will research and make charts listing composites/advanced materials and their applications.

Evaluation: Examine charts, unit test

Unit II - Characteristics of Composite Materials

Class Hours - 4

A. The specific ingredients of composites/plastics

Discuss characteristics of composites and their ingredients. Use the chalkboard to list the following:

1. Resins and their characteristics
2. Fillers and their characteristics
3. Reinforcements (review those from unit 1 and define)
4. Laminates (show samples of composites laminated to materials of wood, plastics, etc.)
5. Surface veils-their advantage as environmental protection for composites and creating ease of handling
6. Solvents and their uses
7. Lubricants
8. Plasticizers and their uses
9. Stabilizers and their uses
10. Antistatic agents and their uses
11. Pigments
12. Catalysts and promoters
13. Flame-retardant additives
14. Viscosity-the stiffness of liquid

Read chapter 6 in Industrial Plastics

B. The Chemical Resistance of Polyesters

At the chalkboard discuss the following with respect to the chemical resistance of polyesters.

1. Acids and bases
2. Oxidation (rust)
3. The effect of temperatures
4. The effect of time

5. Materials testing for desired results

6. Selecting the best resin for the environment

Read pages 89 and 90, and the chart on p. 90 in Industrial Plastics

C. Environmental properties of composites (pultruded fiberglass plastics)

Discuss the following environmental properties of composites (pultruded composite plastics):

1. The effect of temperatures

2. The effect of weathering

D. Electrical properties of composites

Demonstrate/discuss the following electrical properties of composites:

1. Their dielectrical properties; use a current test

2. The possibility of making composites conductive

Read page 92 in Industrial Plastics

E. Mechanical properties of composites

Lecture and use chalkboard to illustrate the following mechanical and physical properties of composites:

1. Tensile strengths

2. Flexural modulus

3. Compressive strength

4. Impact strength (Barcol Hardness)

5. Coefficient of thermal expansion.

Read pages 74-85 Industrial Plastics.

Show chart of physical properties of pultruded composites in Creative Pultrusion's Design Guide, p. 3-4.

F. Compare the strengths of composites with the strengths of other materials

Provide student with bar graph, p. 2-5, Creative Pultrusions Design Guide, showing material strengths and discuss the following:

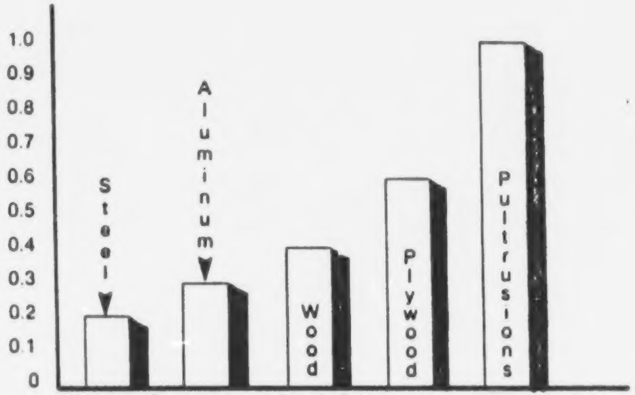
1. Strength to mass ratio

2. The strength of steel per unit weight

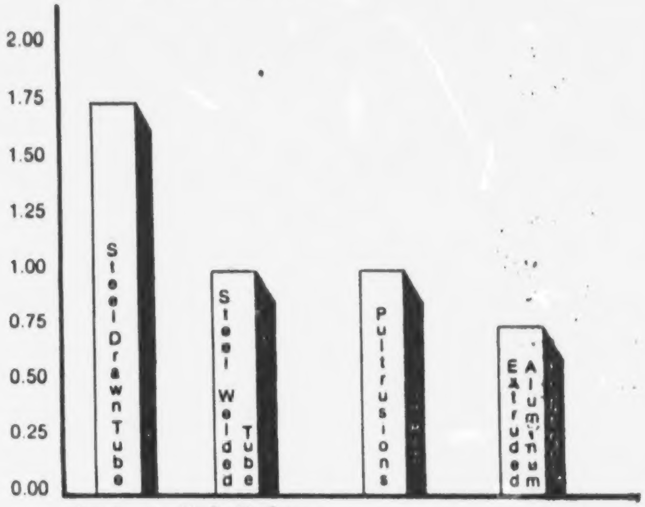
3. The strength of aluminum per unit weight

MATERIAL COMPARISON

Pultex Fiberglass will not always be the material of choice when selecting materials for an application. When the benefits of fiberglass are not required, other competitive material costs will prove more economical.



Strength per Unit Weight



Cost per Unit Volume

The charts above demonstrate the comparative cost and strength of pultrusion fiberglass versus other materials justifying further evaluation of the benefits of each material in relation to the others being considered.

Energy Content

In these days of conservation, another factor to consider when analysing materials is the total energy output required in order to produce the product. A product of Pultruded Fiberglass requires far less energy to produce than one made of metals. Pultex profiles require 2/3 the energy to produce an identical shape in steel and 1/3 that needed to make one in aluminum. As a result, the susceptibility to escalating energy cost is greater for metal than for Pultex Fiberglass. This should be a consideration in any long-term, high-volume applications.

Used with permission, from Creative Pultrusion's Design Guide, page 2-5.

4. The strength of wood per unit weight

5. The strength fo plywood per unit weight

6. The strength of pultruded composites per unit weight

Evaluation: Unit Test

Unit III - Design Considerations: Processing Composite Materials

Class Hours - 4

A. Manufacturing Processes

Discuss and illustrate. List the following at the chalkboard:

1. Design (engineering, design, drafting)
2. Planning (plan of procedure)
3. Layout
4. Cutting and shaping
5. Forming
6. Fastening
7. Finishing

Read Chapter 18 in Industrial Plastics

Evaluation: Unit Test

B. The eight basic design considerations

Discuss and List the following at the blackboard:

1. Environment
2. Appearance
3. Electrical properties
4. Chemical properties
5. Mechanical factors
6. Economics
7. Processes of manufacture
8. Design limitations

Evaluation: Unit Test

C. Use of CAD/CAM/CAMM in manufacturing composites/advanced

RESIN PROPERTIES

Property	Polyester	Vinylester	Epoxy
Tensile Strength, [psi]	11,200	11,800	11,000
Tensile Modulus [psi x 10^5]		4.9	4.8
% Elongation	4.2	4.5	6.3
Flexural Strength, [psi]	17,800	19,400	16,700
Flexural Modulus, [psi x 10^5]	4.6	4.5	4.7
Heat Distortion [Temperature °F]	170	210	330
Barcol Hardness	40	30-38	50
Specific Gravity	1.13	1.12	1.28

Fillers

Various fillers are also used in the pultrusions process. There are three major fillers. **Aluminum Silicate,** (kaolin clay) is used for improved chemical resistance, opacity, good surface finish, and improved insulation properties. **Calcium carbonates** offer improved surfaces, whiteness, opacity and general lowering of costs. **Alumina trihydrate** and **Antimony trioxide** are used for fire retardancy. Alumina trioxide can also be used in conjunction with clays for improved insulation properties.

PHYSICAL PROPERTIES OF PULTEX™ SHAPES

Roving Reinforced

Property (coupon values)	Unit	65 to 70% glass 1	70 to 75% glass 2
Tensile Strength	psi	100,000	120,000
Tensile Modulus	psi x 10^6	6	6.5
Flexural Strength	psi	100,000	120,000
Flexural Modulus	psi x 10^6	6	6.5
Compressive Strength	psi	60,000	70,000
Izod Impact Strength	ft.-lbs./in.	40	40
Barcol Hardness	— —	50	50
Water Absorption	Maximum %	.25	.25
Density	lbs./in.^{3}	.073	.074
Specific Gravity	— —	2.0	2.0
Coefficient of Thermal Expansion	in./in./°C	5.2 x 10^{-6}	5.2 x 10^{-6}

1 — Hollow rounds reinforced with roving only.
2 — Standard round rods and bars.

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PHYSICAL PROPERTIES OF PULTEX SHAPES

Property (coupon values)	Unit	Series 1500 & 1525 Mat + Roving Reinforced Parts 40 to 45% glass Longitudinal	Transverse	Series 1625 Mat + Roving Reinforced Parts 40 to 45% glass Longitudinal	Transverse
Tensile Strength	psi	30,000	7,000	37,500	10,000
Tensile Modulus	psi x 10^6	2.5	.8	3.0	1.0
Flexural Strength	psi	30,000	10,000	37,500	14,000
Flexural Modulus	psi x 10^6	1.6	.8	2.0	1.0
Izod Impact	ft.-lbs./in.	28	4	30	5
Compressive Strength	psi	30,000	15,000	37,500	20,000
Compressive Modulus	psi x 10^6	2.5	1.0	2.5	1.2
Barcol Hardness	—	50	—	50	50
Shear Strength	psi	5,500	5,500	7,000	6,000
Density	lbs./in.^{3}	.058-.062	—	.058-.062	—
Specific Gravity	—	1.61-1.75	—	1.61-1.75	—
Coefficient of Thermal Expansion	in./in./°C	5.2×10^{-6}	—	5.2×10^{-6}	—
Water Absorption	Max. %	.6	—	.5	—
Full Section Deflection Tests Modulus of Elasticity	psi x 10^6	2.5	—	2.8	—
Tensile Strength	psi	20,000	—	25,000	—
Compressive Strength	psi	20,000	—	25,000	—

SUPERSTUD™ PROPERTIES

Superstuds™ are produced in flame retardant Vinylester resin, gray in color. This resin is classified as self-extinguishing per ASTM D-635 or maximum 25 flame spread per ASTM E-84-80.

	Diameter — Threads Per Inch ⅜-16 UNC	½-13 UNC	⅝-11 UNC	¾-10 UNC	1-8 UNC
Ultimate thread shear strength — Tensile loading[1] [2] (lb./in. of thread engagement)	2,500	4,000	5,200	6,460	6,580
Max. design tensile load using standard MP full nut (lb.)	1,000	2,000	3,120	4,520	6,200
Ultimate thread shear using standard MP full nut[2] (lb.)	1,250	2,500	3,900	5,650	7,400
Flexural strength[2] [3] ASTM-D-790 (psi)	60,000	60,000	60,000	60,000	60,000
Flexural modulus[2] [3] ASTM D-790	2.0×10^6	2.0×10^6	2.0×10^6	2.5×10^6	2.75×10^6
Compressive strength — Longitudinal[2] [3] ASTM-D-695 (psi)	55,000	55,000	55,000	55,000	60,000
Ultimate transverse shear — Double shear[2] [3] ASTM B-565 (load lb.)	4,200	7,400	11,600	17,200	27,400
Transverse shear yield — Double[2] [3] (load lb.)	2,100	3,300	4,500	7,500	12,500
Dielectric strength[2] [3] ASTM D-149 (kv/in.)	40	40	40	40	40
Water absorption, 24 Hr. immersion — Threaded[2] ASTM D-570 (%)	1	1	1	1	1
Coefficient of thermal expansion — Longitudinal per °F	5.2×10^{-6}	5.2×10^{-6}	5.2×10^{-6}	5.2×10^{-6}	5.2×10^{-6}
Tension induced by torquing with MP full nut and SAE 10W30 motor oil (lb.)[4]					
50% of ultimate torque	325	490	1,065	1,480	2,300
75% of ultimate torque	730	895	1,815	2,050	3,030
Ultimate torque strength using MP full nut lubricated with SAE 10W30 motor oil[2] (ft.-lb.)	8	15	33	50	115
Stud weight[3]	.076	.129	.209	.315	.592

[1] Applies to single nut only — multiple nuts do not yield corresponding results

[2] Ultimate strength values are averages obtained in design testing

[3] Values are based on unthreaded rod

[4] Torque results are very dependent on several variable factors including the lubricant used, the length of the stud between nuts, alignment, washer surfaces, etc. Therefore if results of torque tightening are important, it is vital that torque limits be determined experimentally for the exact installation conditions

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materials

Demonstrate briefly and define the following:

1. CAD/CAM

Discuss and illustrate the following at the blackboard:

2. CAMM

D. Other design considerations

Discuss and show pictures of the following:

1. Prototypes (describe here or in the design section)
2. Performance and service tests
    a. Water absorption
    b. Dielectric strength
    c. Thermal conductivity
    d. Weathering
    e. Flame retardance
    f. Compressive strength
    g. Demonstrate materials testing; have students perform tensile strength test on 3 composite materials and on aluminum alloy.

Evaluation: Materials, Tests, and Unit Test

Discuss the following:

3. The importance of material shrinkage
4. Dimensional tolerances (show mechanical drawing for concept)
5. Parting lines (show example). See pages 520,523,529, and 530 in Industrial Plastics.

Evaluation: Unit Test

E. Reinforced plastics molding processes

Look at the chart on Pages 533 and 534 of Industrial Plastics and discuss the following molding processes (emphasize pultruding):

UNIT IV - DESIGN AND DRAFTING - CAD UTILIZATION FOR ADVANCED MATERIALS AND PROCESSES

SUMMARY OF UNITS 1-7 ON CAD:

The CAD curriculum additions are in seven primary units. The first unit is an introduction to CAD/CAM terminology, hardware, software, and basic CAD concepts. The second unit deals with the creation of line entities, primary display options, and the creation of points, circles, arcs, and splines. Unit three is the utilization of the delete and edit functions, and the changing and setting of attributes such as line type, line width, and pen numbers. Unit four teaches the use of levels, snap, grids, file handling, and the use of plotters and printers. Unit five introduces dimensioning, verifying attributes of entities, and crosshatching. The sixth unit teaches the use of transformations, rotation, scaling and mirroring. Finally, unit seven deals with the creation of 3D wireframe models, and the use of pattern files to create multiview, and assembly drawings.

Due to the copyright laws and proprietary rights that cover the sale and use of CAD software and its manuals, it will be required that educators who want to utilize this curriculum purchase the software and manuals for a specific CAD application. An effort has been made to make this curriculum as "generic" as possible (but still remain useful) so that it can be used as a guide for teaching basic CAD concepts with any CAD software.

1. Contact

2. Vacuum bag

3. Matched die

4. Pultruding

5. Filament wound

6. Spray molding

Read pages 324-331 of Industrial Plastics

Activity: Make Clipboard using matched-die molding (emphaseze safety)

Read page 347-349 of Industrial Plastics

Evaluation: Project, Unit Test

SECTION V-e - TEACHING AIDS

TEACHING AIDS

Unit I

A. Plastics as a base for composites

Reference: Industrial Plastics: Theory and Application, Chapter 1, pp. 30, 31, 35, and 36.

B. Identification of composites and advanced materials, and their applications

Reference: Industrial Plastics; Theory and application, pp. 144-149.
Sample of composites, plastics and advanced materials
Overhead transparency showing pultruded composites
Picture from Creative Pultrusion's Design Guide showing applications of composites
Picture/blueprints showing applications of advanced materials (aluminum alloy)

Unit II - Characteristics of Composite Materials

A. Specific Ingredients

Sample of laminates using composites

References: Industrial Plastics, Chapter 6; Creative Pultrusion's Design Guide, Chapter 1

B. The Chemical Resistance of Polyesters

Chart, Industrial Plastics, pa 90.

References: Industrial Plastics, Chapter 4 (pp.89-90.) Creative Pultrusion's Design Guide - Chapter 4.

C. Environmental Properties

References: Industrial Plastics, Chapter 4 (pp.89-90.) Creative Pultrusion's Design Guide - Chapter 4.

D. Electrical Properties

References: Industrial Plastics - p. 92; Creative Pultrusions, pp 3-3 and 3-7

E. Mechanical Properties

Handout: Physical Properties of Pultex Shapes - Creative Pultrusions pp. 3-3, 3-4

References: Individual Plastics, pp 74-85;

Creative Pultrusions, pp. 3-3 to 3-6

F. Compare the Strenghts

Handout: Material Comparsion - Creative Pultrusions, p. 2-5

Unit III - Design Considerations

A. Manufacturing Processes

Reference: Industrial Plastics, chapter 18

B. The eight basic design considerations

Reference: Industrial Plastics, chapter 18

C. Use of CAD/CAM

Reference: Industrial Plastics, chapter 18, p. 517

D. The eight basic design

References: Industrial Plastics, chapter 4 and chapter 18, pp. 520, 523, 529 and 530; and Creative Pultrusions, pp. 3-5 and 3-6

E. Reinforced Plastics

Chart: Plastics Processing forms - Processes, Advantages, Limitations, Industrial Plastics, pp. 533-534

References: Industrial Plastics, pp. 321-331 and (matched-die reinforcing molding activity) pp. 347-349.

Unit V - Safety

A. Chemical hazards

Reference: Industrial Plastics, chapter 3

B. Possible effects

Reference: Industrial Plastics, chapter 3

C. Physical hazards

Reference: Industrial Plastics, chapter 3, p. 47

D. Biological

Reference: Industrial Plastics, chapter 3

E. Non-toxicity

Reference: Industrial Plastics, chapter 3

F. Specific health

Table: Toxicity and health hazards of selected materials, Industrial Plastics, p 48.

Reference: Industrial Plastics, chapter 3

G. Proper Storage

Reference: Industrial Plastics, chapter 3

H. Fire Toxicity

Reference: Industrial Plastics, chapter 3

I. Proper mixing

Job sheet: Contact molding a skateboard

References: Industrial Plastics, chapter 3, p. 39 and p. 326; and Manufacturing: A Basic Text for Industrial Arts, pp. 268-271

J. Explosiveness

Chart: Explosion characteristics of selected dusts used in the plastics industry, industrial plastics, p. 590.

Reference: Industrial Plastics, p. 49

K. Factory safety

Reference: Industrial Plastics, pp 50 and 51; and Creative Pultrusions, p. 7-2

L. Protective Clothing

Reference: Industrial Plastics, p. 51

M. Fire prevention

Transparency: Selecting the proper class fo fire extinguishers

Reference: Industrial Plastics, pp. 50-51

N. Equipment accident prevention

Posters: Stanley Safety Posters

Reference: Industrial Plastics, p. 51

O. Individual

Reference: Pennsylvania Industrial Arts/ Technology Education Safety Guide, 3rd Edition.

Note: Check machine manual for latest high-tech machines and follow manufacturers safety instructions

P. OSHA

Reference: Industrial Plastics, p. 51-52

Unit VI - Machine Processes

A. Similarities

Reference: Industrial Plastics, chapter 9

B. Decimal

Reference: Consult a junion high school math textbook

C. Reading

Reference: Technology of machine tools, units 9 and 10

D. Blueprint Reading

Reference: Blueprint reading and technical sketching for industry

E. Blade

Reference: Creative Pultrusions, p. 7-10; and Industrial Plastics, chapter 9

F. Cooling Agents

Reference: Industrial Plastics, p. 265, and Creative Pultrusions, p. 7-2

G. Rake Angles

Reference: Industrial Plastics, pp 266 and 269

H. Set

References: Industrial Plastics, p. 266; and Creative Pultrusions, p. 7-10

I. The proper number

Chart: Power Saws for cutting plastics, Industrial Plastics, p. 267, table 9-1

References: Industrial Plastics, p. 266; and Creative Pultrusions, p. 7-10

J. Bandsaw

Reference: Creative Pultrusions, p. 7-10

K. Drilling

References: Industrial Plastics, pp. 268-269, and Creative Pultrusions, pp. 7-10 and 7-11

L. Machine speed

References: Industrial Plastics, pp. 266-270; and Creative Pultrusions, p. 7-10

M. Other

Reference: Creative Pultrustions, pp. 7-1 to 7-11

N. Grinding

Reference: Creative Pultrusions, p. 7-11

O. Punching Operations

References: Creative Pultrusions, pp. 7-13 to 7-18

P. Shearing Operations

References: Creative Pultrustions, p. 7-18

Q. Threading

Reference: Industrial Plastics, p. 270

R. Jigs/

Reference: Manufacturing, pp. 404-409

Note: The author saw multiple blades set up on a mandrel at local reinforced plastics factories

S. Climb cutting

Reference: Industrial Plastics, p. 272

T. Unique

Reference: Industrial Plastics, pp. 272-274

Unit VIII - Fabrication Processes (Fastening Techniques)

A. Bonding Techniques

Chart: Comparison of Adhesives used with Pultex Shapes, Creative Pultrusions, p. 7-8

References: Industrial Plastics, chapter 15, and Creative Pultrusions, pp. 7-4.

B. Demonstrating

Reference: Creative Pultrusions, p. 7-7

C. Aluminum Alloy Welding

Reference: Modern Welding, units 11 and 12

D. Mechanical Fasteners

Information Sheets: Comparison of Joining Techniques, Creative Pultrusions, p. 7-8 and Mechanical

Fastenings, Creative Pultrusions, pp. 7-22 and 7-23

Reference: Creative Pultrusions, pp. 7-3, 7-22, and 7-23

E. Applying

Reference: Creative Pultrusions, pp. 7-3, 7-22, and 7-23

F. Joint Design

Information Sheets: Bonded shear joint concepts, Creative Pultrusions, p. 7-5

Reference: Creative Pultrusions, p. 7-5 and 7-6

G. Fabricating

Reference: Creative Pultrusions, p. 7-5 and 7-6

H. Composite

Transparencies: Joining Standard Structurals, Creative Pultrusions, pp. 7-20 and 7-21

Reference: Creative Pultrusions, pp. 7-20 and 7-21

I. Fabricating

Reference: Creative Pultrusions, pp. 7-20 and 7-21

Unit IX - Finishing Operations

A. Preparation

Reference: Creative Pultrusions, p. 7-19.

B. Actual

Reference: Creative Pultrusions, p. 7-19

C. Applying

Reference: Creative Pultrusions, p. 7-19

Unit X - "Other Technical Occupations in the Composites Industry"

A. Technical Occupations

Reference: Creative Pultrusions, chapter 3, chapter 4, and p. 6-1

B. Trip to composites factory

Reference: All previous materials noted

SECTION V-f - STUDENT PROJECTS

PROJECTS

Activities that will be concrete learning experiences and reinforce the integrating of material selection, product design, and manufacturing using advanced materials, and CAD/CAM:

Have students draw the details of the parts and the assembly drawing of the project using CAD skills learned in the CAD units. Students will study and discuss the materials being used in the project and the properties of these materials in the Advanced Materials units. Students will then be ready to machine the parts for the assembly using the skills learned in the CAM units of the curriculum which will incorporate their CAD drawing, and any special machine settings, fixtures, and tooling required by the material. Once the parts are machined, the students will inspect them for correctness, and assemble the project using the appropriate type of fasteners or bonding techniques.

Project Materials: Composite pultrusions and aluminum

Composites project's desirable characteristics:

Composites projects are primarily constructed of reinforced fiberglass pultrusion parts cut to appropriate lengths, and machined for appropriate fasteners and joining techniques (joint design dependent). Joint types are selected for the basic types of loading for the specific project and utilize adhesives and aluminum fasteners and brackets where needed.

Desirable characteristics of these projects are that they are economical, strong, lightweight, corrosion resistant, water-proof, non-conducting for electricity, and never need painted (although they may be if desired).

Possible composites projects:

1. Step stool or foot stool
2. Extension ladder
3. Porch or stairway handrails
4. Decorative fence
5. Grape arbor
6. Picnic bench
7. Park bench
8. Portable greenhouse or hotbed frame to support clear plastic cover
9. Rose or vine trellis
10. Rack for hanging gardening tools
11. Storage bins for nuts, bolts, washers, screws, etc.
12. Travel trailer parts
13. Fishing pole or pole holder
14. Car-top carrier

15. Portable hunting stool
16. Whip antenna for car
17. Book shelf or case
18. Pickup truck side boards
19. Lawn or farm gate for fence
20. Skate board
21. Clipboard
22. Gun rack for pickup truck
23. Tool handles

Possible metals projects utilizing CAD/CAM:

1. Plaque with initials
2. Belt buckle with initials or "METAL FAB"
3. Block with part inside
4. Address plate for house or mailbox
5. Name plate for house or mailbox
6. Name plate for front of car

Composites Project

The final project for the students utilizes skills and techniques learned throughout the curriculum - CAD, CAD/CAM, and knowledge of machining, joining, and working with composite structural members of pultruded reinforced fiberglass. The project is a small boat trailer designed and built primarily of composites with a few aluminum brackets.The boat trailer is designed for 10 to 14' boats and has a load capacity of approximately 600 lbs. Testing on a prototype of the boat trailer will be done, to verify the ability of the trailer to be rated at higher capacity. All structural members are made from standard pultruded reinforced fiberglass plastic structural beams, angles, sheets, and channels. Standard sheet aluminum is used for a few brackets, and the remaining trailer parts are standard trailer items available at Sears and J. C. Whitney Co.

The non-corrosive and light-weight properties of the composite materials and aluminum make these materials ideal for fresh or salt water boat trailers. Currently there are no trailer frames of any type which are constructed of composites, which make this project unique, as well as extremely marketable for an inovative, small company run by students graduates. This may represent a very good opportunity for a business venture of graduates working cooperatively with a local manufacturer of the composite materials. Costs appear to be slightly higher than the conventional steel framed boat trailer, but longer life expectancy should offset this disadvantage. Marina operators at local lake marinas attest there is a market for small boat trailers of this type.

SECTION V-g - EVALUATION

EVALUATION METHODS

Unit I - Introduction to Composites/Advanced Materials

A. Unit Test

B. Unit Test and research activity

Unit II - Characteristics of Composite Materials

A. Unit Test

B. Unit Test

C. Unit Test

D. Unit Test

E. Unit Test

F. Unit Test

Unit III - Design Considerations: Processing Composites Materials

A. Unit Test

B. Unit Test

C. Unit Test

D. Unit Test amd materials tests

E. Unit Test and project grade for clipboard

Unit V - Safety

A. Unit Test

B. Unit Test

C. Unit Test

D. Unit Test

E. Unit Test

F. Unit Test

G. Unit Test

H. Unit Test

I. Unit test and project grade for skateboard and the safe mixing of promoters and catalysts

J. Unit Test

K. Unit Test

L. Unit Test

M. Unit Test

N. Unit Test

O. Safety tests for each machine, and a safety evaluation on the students use of each machine

P. Unit Test

Unit VI - Machine Processes

A. Unit Test

B. Quiz

C. Measuring tests of 10 samples with the micrometer and vernier caliper. Also all projects must meet accuracy requirements.

D. Two mechanical drawing reading tests

E. Unit Test

F. Unit Test

G. Grinding a zero rake angle on a twist drill

H. Unit Test

I. Unit Test

J. Unit Test

K. Evaluate hole size and smoothness in projects

L. Evaluate project edges for fraying or burning

M. Evaluate structural joint projects for ± 1/6" accuracy and observe students to see that correct machining techniques are used.

N. Evaluate projects for smooth edges and proper tool techniques.

O. Evaluate projects on punched-hole locations, taking into account that composites (frp) hole tolerances must sometimes be large.

P. Unit tests and projects that require shearing operations

Q. Evaluate threads cut for project bolts.

R. Jigs, fixtures and/or a multiple blade set-up

S. Climb cut alloys and plastics projects parts

T. Unit Test

Unit VIII - Fabrication Processes (Fastening Techniques)

A. Unit Test

B. Adhesive bonding or projects

C. TIG welded projects (lead contour and penetration)

D. Unit Test

E. Selection and use of mechanical fasteners on projects.

F. Unit Test

G. Selection of proper joints on projects, unit test

H. Unit Test

I. Examine structural joints in terms of accuracy, the proper joint for the application, and assembly with proper fasteners.

Unit IX - Finishing Operations

A. Unit Test

B. Check the finish on projects for smoothness, lack of scratches, and adherence of finish.

C. Smoothness of project finish and completeness of coverage.

Unit X - Other Technical Occupations in the Composites Industry.

A. Research project

B. Student participation

SECTION V-h - BIBLIOGRAPHY

BIBLIOGRAPHY

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SECTION V-i - INSTRUCTOR'S NOTES FOR TEACHING CAD WITH CADKEY

INSTRUCTOR'S NOTES FOR TEACHING COMPUTER-AIDED-DRAFTING WITH CADKEY

INTRODUCTION - [reference "Using Cadkey"]

Terminology - CAD, CAM, CAD/CAM, CIM

CAD - use of computer hardware, software, and peripheral devices to produce graphical images.
   Applications:
      Engineering and technical drawings, electronic, mechanical, and architectural drawings, business graphics, technical illustrations, etc. CAD software generally limited to effectively produce only 2 or 3 of these applications.

CAM - automation of manufacturing processes using computer-controlled machines and robots for fabrication, assembly, mat'l handling, measuring, inspecting, etc. Some of these operations are created using the geometric data base created with the CAD software.

CAD/CAM - umbrella process which merges the design and manufacturing processes into one integrated approach through the use of computers and the sharing of data.

CIM - is the total automation and computerization of the manufacturing process from receipt of the order to shipment of the product. A common data base must be available to all phases of the sales, engineering, manufacturing, inspection, and shipping operations.

CAD systems:
Hardware - Computer system usually consisting of:
   Central Processing Unit (CPU)-computer chips
   Input devices (keyboard, mouse, digitizer tablet)
   Output devices (CRT)
   Storage devices (floppy diskettes, hard disk)
   Output devices (printer, plotter)
Software - CAD programs (AUTOCAD, CADKEY, ROBOCAD, VERSACAD, etc.)

Drawings are special computer files which consist of all the "entities" required to make the drawing. These drawings are stored on diskettes or hard disks.
Entity types: lines, arcs, circles, splines, points, polygons, notes, dimensions, labels.
The ability to manipulate entities or groups of entities for the purpose of copying, translating, rotating, scaling, or mirroring make CAD an extremely useful and efficient tool for drafting and designing.
GENERALLY - DRAW A PART ONLY ONCE

BRIDGES BETWEEN THE VARIOUS CAD SYSTEMS THAT PERMIT CAM:
Possibility of drawing/data transfer between CAD systems via DXF files (Drawing Interchange Format - the 2D "standard") and via IGES files (Initial Graphics Exchange Standard - the 3D "standard"). These files are essentially ASCII (text-type) files with standardized formats which permit translator programs to interpret a generic CAD drawing and translate the file into a CAD file of a specific software type.

CHAPTER 1 - EXPLORING CADKEY - STARTING AND CREATING LINES:

CADKEY SCREEN DISPLAY - "windows" are areas on the screen

Drawing window and cursor (pointer controlled by mouse or keyboard)
Graphic display area for drawing
Cursor - pointing device manipulated via mouse, keyboard arrows, digitizer tablet, joy stick, track ball, etc.

Menu window - list of options from which to choose via function keys or cursor selection

Status window - set of 3 pages of menus which indicate system parameters which may be changed. [some represent short cuts to the menu options] Pages may only be changed by selecting "more", which will cause the next page to be displayed. Repeated selections of "more" will result in cycling through the 3 status window pages.

Cursor tracking window - display of the cursor location

History line - an on-screen record of the functions which have been selected

Prompt line - prompts to tell user when to choose an option, enter a value, locate a position, or select an entity, etc.

[SHOW AREAS USING CREATE-LINE-ENDPOINTS example]

MENU "TREE" STRUCTURE - main menu and sub-menus
Note history line and prompt line indicate sequence or menu choices.
Choices via mouse selection or Function keys (F1-F10)

COORDINATE SYSTEMS
View coordinates - screen reference => directions independent of view displayed, designated by XV,YV,ZV

World coordinates - absolute reference => directions dependent on view displayed, designated by X,Y,Z

IMMEDIATE MODE COMMANDS:

CTRL-T	cursor tracking
CTRL-G	grid on/off
CTRL-X	snap on/off
CTRL-R	redraw
CTRL-Q	delete single
CTRL-U	undelete last
ALT-A	autoscale

CREATING ENTITIES:

USING CREATE, LINE, AND POSITION MENUS:

Drawing a rectangle using [create-line-endpts] with key-in positioning
   Create-line-endpts-key-in, 4x2 rectangle w/ 1/1 at 0,0,0.
   Delete all lines using CTRL-Q and select entities.

Drawing a rectangle using [create-line-string] with key-in positioning
   Create-line-string-key-in, 4x2 rectangle w/ 1/1 at 0,0,0
   Delete rectangle

Drawing a rectangle using parallel lines and endent positioning
   Create-line-endpts-key-in, bottom line
   Create-line-parallel-at distance, top line
   Create-line-endpts-endent, side lines, diagonals
   Save dwg as FIRSTRY, CTRL-F immediate mode command

Changing line-types and drawing lines using center, intersection, & alongline options in position menu [create-line-endpoints] (center, intrsct, alongl):
   Status window, l-type, dashed
   Create-line-endpts-center, line 7 fig 1-6
   Create-line-endpts-center, then intersection, line 8 fig 1-6
   Create-line-endpts-alongl, then center, line 9 fig 1-6

ASSIGN EXERCISES 1.1-3

Summary of topics covered in chapter 1:
   Screen display areas
   Coordinate systems - view vs. world coordinates
   Using immediate mode commands CTRL-T,G,X,Q,U,R,F and ALT-A
   Saving and retrieving drawing using file-part-save & load
   Creating lines with the endpoints, string, & parallel options
   Deleting using delete-select-all disp-all, and delete-select-single
   Setting line types in status window
   Using the following position menu options:
      cursor, point, endent, center, intersc, alongl, & key-in
   Creating rectangles
   Creating polygons

CHAPTER 2 - SCALING DISPLAY, POSITIONING, CREATING CIRCLES:

SCALING AND POSITIONING THE DISPLAY

Create rectangle, change scale of display using status window
- Create-rectang-wid/ht 4x2 w/ 1/1 at 0,0,0
- Change center of display with status window to u/r of rectangle using cursor positioning
- Change center of display to 1/1 using key-in of 0,0,0
- Create-line-endpts 0,0,0 to -2,-2,0 to observe location then delete

Creating points using position menu options - polar, delta [create-point] (polar, delta):
- Create-point using familiar positioning (cursor, endent, center, etc.)
- Create-point using polar at 2" and 38 degrees from 1/1 of rectangle
- Create-point using delta at dXV=2,dYV=-1,dZV=0 from previous point

Creating circles using the circle menu options [create-circle] (ctr+rad, ctr+dia, ctr+edg, three-p, tangent, two-pts):
- Ctr+rad=>input radius, position center
- Ctr+dia=>input diameter, position center
- Ctr+edg=>position center, position pt on circle
- Three-p=>position any three pts on circle
- Tangent=>(2 ents, ctr-ent)
  - 2 ents=>input radius, select 2 entities
  - Ctr-ent=>select tangent entity, position center
- Two-pts=>position of any two pts on diameter of circle

ASSIGN EXERCISES 2.1-5

Summary of topics covered in chapter 2:
- Setting scale of display and center of display using status window
- Creating point entities
- Using the position menu options polar and delta
- Creating circles with the following methods:
  - Center and radius
  - Center and diameter
  - Center and a point on the circle
  - Three points on the circle
  - Radius and two tangent entities
  - Center and one tangent entity

CHAPTER 3 - ZOOMING, CREATING ARCS AND SPLINES:

ZOOMING AND PANNING

Using the display menu options for zooming and panning [display] (zoom, pan):

Zoom => changing the scale of the display using the following options:

- window - indicate rectangular area to have displayed
- scale - select zoom (scale display) factor and center of display
- half - shrink to 1/2 current size with current center of display
- double - enlarge to twice current size with current center of display
- auto - display entire drawing as large as possible
- back-1 - show previous display (up to 2 previous, then cycle)

Pan => keeps current display scale but prompts for new display center

Immediate mode commands for panning and zooming

ALT-A	autoscale
ALT-B	back-1
ALT-D	double scale
ALT-H	half scale
ALT-P	pan
ALT-S	scale
ALT-W	window

CREATING ARCS

Creating arcs using the arc menu options [create-arc]
(ctr+rad, ctr+dia, ctr+edg, three-p, tangent, beg+end, round):

- Ctr+rad=>input radius, start & end angles, position center
- Ctr+dia=>input diameter, start & end angles, position center
- Ctr+edg=>input start & end angles, position center and pt on arc
- Create-arc-three-p, position 3 pts (beg, next, end)
- Tangent-2 ents=>input start & end angles, radius, select two entities
- Beg+end=>input included angle, position beg+end pts [arc drawn ccw]
- Round=>select tangent entity, position of end pt, select cw or ccw

CREATING FILLETS AND CHAMFERS

Creating fillets using the fillet menu options [create-fillet]
(trim, no trim):

- Trim=>input radius, select two entities
- No trim=>input radius, select two entities

Creating chamfers using the chamfer menu options [create-chamfer]:

- Chamfer=>input 1st & 2nd distance, select 1st & 2nd lines

MORE LINE MENU COMMANDS

Creating horizontal and vertical lines using the line hrz/vrt menu options [create-line-hrz/vrt] (horiztl, verticl, both):
NOTE: line(s) will be drawn to current l-limits setting.
   Horiztl=>position pt on line
   Verticl=>position pt on line
   Both=>position pt at intersection of horizontal and vertical lines

Creating perpendicular lines to a reference line
   Create-line-perpend, select ref line, position pt

Creating lines tangent to circles and arcs
   Create-line-tangent-2 arcs, select two arcs/circles
   Create-line-tangent-arc pt, select arc/circle, position of pt

Creating lines at an angle to a reference line
   Create-line-angle, select line near desired end, input angle to reference line [ccw +]

Creating a sketch line
   Create-line-sketch, group (or not), draw freehand line string

CREATING SPLINES

Creating a 2D closed spline
   Create-spline-2d clsd, position pts (3-75) on curve

Creating a 2D cubic spline - Note defining beginning and end conditions
   Create-spline-2d cubi, position pts (2-75), specify start and end tangent directions [natural, 2 pts, endent, tangent, angle]:
      Natural=>no additional constraints on end
      2 pts=>position two pts that define desired slope
      Endent=>select entity near end which has desired slope
      Tangent=>input x,y components of tangent vector
      Angle=>input angle and magnitude of tangent vector

ASSIGN EXERCISES 3.1-4

Summary of topics covered in chapter 3:
- Using the display menu options for zooming and panning
- Using the immediate mode commands for zooming and panning
- Creating arcs using all the arc menu options
- Creating fillets an chamfers
- Creating horizontal and vertical lines
- Creating perpendicular lines, tangent lines, and lines at an angle to a reference line
- Creating freehand sketch lines

CHAPTER 4 - DELETING ENTITIES AND EDITING ENTITIES ON DRAWINGS:

DELETING ENTITIES FROM DRAWINGS

Deleting entities using the selection menu options [delete-select] (single, chain, window, group, all display):

- Single=>select entities
- Chain=>select 1st entity, pt for direction, select last entity
- Window=>indicate rectangular area to completely enclose entities
- Group=>select entity in desired group or name group
- All disp=>all, by type, ex type
  - All=>all entities even partly in display
  - By type=>select desired entity types to be deleted in display
  - Ex type=>select desired entity types to remain in display

NOTE: IF A SELECTED ENTITY BELONGS TO A GROUP OR SUBGROUP, YOU WILL BE ASKED IF YOU WANT TO DELETE THE GROUP, SUBGROUP, OR ONLY THE ENTITY.

Masking entities using the ALT-M immediate mode command

Masking is a method of specifying entity types which may be selected. Masking can therefore be used to help point to only the desired entities to be selected.
ALT-M causes masking menu to be displayed. [lists types of entities] Doing so in the process of selecting entities to be deleted will allow finer control of the "pointing" process. (i.e. only select an arc vs. a line which is very closeby) ALT-M may be used with single or window selecting.

EDITING ENTITIES ON DRAWINGS

The editing menu is primarily used to in correcting, altering, adjusting or repositioning entities or in regenerating unintentionally deleted entities.

Trimming or extending entities using the edit menu options [edit-trm/ext] (first, both, double, divide, modal):

Used to shorten or lengthen lines or arcs to intersections (or potential intersections) of other entities. Also used to shorten splines or transform circles into arcs.

- First=>select entity on portion to remain, select trimming entity
- Both=>select entities on portions to remain, trims both
- Double=>select entity on portion to remain, select trimming entities
  (THIS IS THE ONLY TRIMMING METHOD THAT MAY TRIM CIRCLES)
- Divide=>select entity on portion to remove, select trimming entities
- Modal=>select trimming entity, select successive entities on portions to remain

Breaking entities using the edit menu options [edit-break] (first, both, double, divide, modal):

Used to break an existing entity into two or more entities at an existing intersection with other entities (useful when crosshatching and geometric analysis) or to change the attributes (i.e. color, l-type, l-width, pen#, level, etc.) of portions of existing entities.

Options first, both, double, divide, and modal function like with trm/ext except that the entities become broken rather than shortened or lengthened. If an intersection does not exist, an error message will occur. If the current attribute settings differ from the original attribute of the broken entity, the entity portion that would have been removed using trm/ext takes on the current attribute setting.

Recalling entities previously deleted using the edit menu options [edit-recall] (last, level, all):

Used to regenerate entities deleted by a previous command. ONLY ENTITIES DELETED DURING AN ON-GOING WORK SESSION CAN BE RECALLED.

Last=>regenerate last entity deleted
Level=>regenerate all entities deleted from a specified level
All=>regenerate all entities deleted since last execution of files-part-load or system start-up if no part has been loaded. Choose all, by type, or ex type.

Moving entities using the edit menu options [edit-bx move] (x-y, base pt):

Used to move selected entities to new positions. Select entities by creating a window to entirely enclose entities.

X-Y=>input desired horizontal and vertical shift
Base pt=>position of base pt, new position of base pt

Grouping entities using the edit menu options [edit-group] (make, add to, degroup, delete, list):

Used to link entities together so they may be selected as a unit. (delete, move, rotate, scale, mirror, etc.)

Make=>input group name, select entities to be included in group. If a group of this name already exists, you will be asked if you want to create a subgroup.
Add to=>input existing group name, subgroup name, select entities
Degroup=>select entities, group or subgroup
Delete=>input group name, all group entities will be degrouped & group name (NOT ENTITIES) will be deleted from the drawing
List=>listing of all group names contained in current drawing

Creating line and arc segments using the edit menu options [edit-autoseg] (ents, lines):

Used to create a specified number of new line or arc entities overlaying existing lines, arcs, or circles. Ents option will create a specified number (2-200) line segments on a lines or arc segments on arcs. Lines option will create a specified number of equal length line segments on a line, arc, circle, or spline. If an arc or circle is selected, you will be asked for start and end angles for autoseg.

Ents=>select entity, input number of segments
Line=>select entity, input number of segments

CONTROLLING ATTRIBUTES OF ENTITIES

Controlling attributes of entities using the control menu options [control-attrib] (color, l-type, l-width, pen#):

Used to set current attributes or change attributes of an entity. (color, line type, line width, or pen#) Select or input desired choice. Two options of each are current or change.

Current=>subsequent entities sill have specified attribute
Change=>select attribute type, select entities

ASSIGN EXERCISES 4.1-6

Summary of topics covered in chapter 4:

- Deleting entities and using the selection menu options
- Masking entities
- Using the editing menu options:
  - Trimming or extending
  - Breaking
  - Recalling previously deleted entities
  - Making box moves
  - Grouping, adding to groups, degrouping, deleting group names, and listing groups
  - Creating line and arc segments to overlay existing entities
- Setting and changing the color, l-type, l-width, and pen# of entities

CHAPTER 5 - LEVELS, GRIDS, PLOTTING, PRINTING:

SCREEN DISPLAY OF LEVEL, GRID, AND SNAP

Using the display level menu [display-level]
(active, visible, move, list):

Levels can be thought of as a stack of transparent sheets upon which you draw using CAD. A drawing can be made up of as many as 256 levels. Entities may only be created on one level at a time (the active or current working level), but any number of levels may be displayed at any given time. Levels are generally used to organize drawings in a way which:

1. makes it convenient to select, view, or manipulate entities.
2. permits selective plotting of drawing levels.
3. makes it convenient for efficient editing of drawings by multiple CAD operators. (i.e. standard placement of dimensions, construction lines, notes, etc. on specified levels)

NOTE: There may be only one "active" level at any time; this is the level on which you may create entities. Level 256 is reserved for storage of entities which are not to be displayed or plotted.

Active=>input the new level number on which you want to work. (CTRL-L is the immediate mode command, active level is displayed in the status window and may also be changed by cursor selection on ALEV)

Visible=>add or remove selected levels from those which are currently visible. Input multiple levels separated by commas, or a continuous series by entering the first and last level separated by a hyphen (-).

Move=>select entities to be moved and input new level number, or choose to move an entire level to a new level.

List=>displays level numbers currently visible, and can be used to add or remove levels currently visible by cursor selecting the level number on the screen.

Using the grid menu options [display-grid]
(on, off, set X,Y , to snap, align):

Used to provide visual indication of distance on the display.

On=>turn the grid display on at current setting (default .5" for inch configuration)
Off=>turn grid display off, redraw to display
Set X,Y=>input x then y grid setting, redraw to display
To snap=>set and align grid to the current snap settings
Align=>used to position grid such that one of the grid pts coincides with a specified position; indicate position

NOTE: RANGE OF BOTH GRID AND SNAP SETTINGS IS .00005 TO 10000. ALSO NOTE THAT IF THE GRID DISPLAY IS TOO DENSE, IT WILL NOT BE DISPLAYED.

Using the snap menu options [display-snap]
(on, off, set X,Y , to grid, align):

Used to accurately locate cursor at specified increments. Cursor will jump to nearest incremental setting. Commonly used with the grid to draw with both set at a common drawing unit (i.e. .25"). Pressing the page up (PgUp) key will double the current snap setting, and pressing the page down (PgDn) will halve the current snap setting. With cursor tracking on, the current snap setting can readily be determined.

On=>turn the snap on at current setting (default .5" for inch configuration)
Off=>turn snap off
Set X,Y=>input x then y snap setting
To grid=>set and align snap settings to current grid settings
Align=>used to position snap such that one of the snap pts coincides with a specified position; indicate position

Using the display teach system [display-teach]:

Used to display menus from which on-screen help can be accessed by cursor selection.

FILES MENU

Using the part files menu options [files-part] (save, load, lst/ld):

CAD drawings are saved on the computer as part files. Drawings are saved as part files (name.PRT) on diskettes or hard disks. Previously saved drawings may be loaded into the computer for viewing or editing.

Save=>specify name for the part file (preceded by drive if desired)
Load=>replace currently displayed drawing (if any) with specified drawing
Lst/ld=>list all part files (.PRT suffix) in specified directory, cursor select desired drawing to be loaded.

Using the pattern files menu options [files-pattern]
(create, retrieve, lst/rtv):

Patterns are essentially symbols that can be placed on a drawing currently being displayed. This allows combining two or more drawings into a single drawing. Common examples are drawings on which fasteners such as bolts, nuts, screws, etc. are to be shown. Drawings of these fasteners could be created once, saved as patterns and then retrieved into other drawings as needed. This saves an enormous amount of time in creating assembly drawing or on drawings where multiple parts are used (i.e. electrical or piping schematics, furniture for floor plans, construction drawings with standard components such as I-beams, etc.)

Create=>indicate a base position for the pattern, specify a name for the pattern file (name.PTN), and select the entities to be included. (preceded by drive if desired)

Retrieve=>specify pattern name (preceded by drive if desired) of pattern to be retrieved onto current drawing, choose to group pattern or not, and position insertion point (placement of pattern base position), and input scale factor and rotation angle.

Lst/rtv=>list all pattern files (.PTN suffix) in specified directory, cursor select desired pattern to be retrieved.

Using the DXF files menu options [files-dxf] (save, load):

Save=>specify name for DXF file (preceded by drive if desired)

Load=>name of DXF file to be loaded (preceded by drive if desired)

PLOTTING AND PRINTING TO PRODUCE "HARDCOPY"

Using the control menu options for plotting [control-plot] (auto, key-in):

Used to plot the image appearing in the drawing area of the screen. May use standard sizes A-E or any desired size within limits of the plotter. The type of plotter, max paper size, any offsets for centering the plot, plotting speed, and other plotting parameters must be specified during system configuration.

Auto=>plotting scale automatically set so the plotted drawing fills the drawing area of the paper, just as the image on the screen fills the screen area.

Key-in=>input desired scale or accept the default of 1.0 which will make 1 drawing unit equal 1" on the paper.

Once the scale has been selected with either of the above options, you may choice to plot by pen# (i.e. entities drawn with pen1 will be plotted with plotter's pen#1) or by color (i.e. a particular color entity will indicate which plotter pen# will be used). Press Enter key to initiate plotting, and press the escape (Esc) key to stop plotting (allow some time to stop).

It is also possible to do off-line plotting of drawings by using the files-plot menu option to create a special plot file (name.PLT) that may then be plotted by running the Plotfast program.

Using the control menu options for printing [control-print]:

Used to create a "rough" hardcopy of a drawing when plotter is not available. Turn printer on, align paper, and press Enter key. Since ALL images in the drawing area are printed, a redraw should be performed prior to printing.

ASSIGN EXERCISES 5.1-7

Summary of topics covered in chapter 5:

- Using the following level menu options:
  - Active, visible, move, and list
- Using the grid menu to turn grid on/off, & set and align grid
- Using the snap menu to turn snap on/off, & set and align snap
- Using the teach files for on-screen help
- Saving, loading and listing part files
- Creating, retrieving, and listing pattern files
- Saving and loading DXF files
- On-line plotting of drawings
- Off-line plotting of drawings
- Printing of drawings

CHAPTER 6 - DIMENSIONING, CROSSHATCHING, AND VERIFYING:

USING THE DETAIL MENU

Dimensioning drawings using detail menu options [detail-dimensn] (horiztl, verticl, paralel, radius, angular, diametr):

- Horiztl=>position 2 pts, and indicate text position
- Verticl=>position 2 pts, and indicate text position
- Paralel=>distance along an angle, position 2 pts, and indicate text position
- Radius=>select arc/circle, indicate text position & leader side
- Angular=>select two line entities and indicate text position
- Diametr=>select arc/circle, indicate text position & leader side

Default settings for dimensioning are:

- 2 witness lines (extension lines)
- 2 leaders, arrows inside witness lines
- units in 2 decimal places
- height of dimension text .3 units

These may be changed using the detail-set menu options

Creating notes and labels using detail menu options [detail-note & -label]:

- Note=>general notes using text only, choose key-in or disk
  - Key-in=>type in line of text, press enter key after each line or two consecutive times to indicate end of note, indicate text position
  - Disk=>enter filename for note and indicate text position
- Label=>text with a leader line, choose key-in or disk as above, indicate text position and leader side.

Default settings for notes and labels are:

- Lower left corner of 1st line of text is text locating position
- height of note text is .3 units

Changing default settings using detail menu options [detail-set] (arrows, witness, decimal, text, toler, standard, units, leaders, ver dim):

- Arrows=>select in or out, also via CTRL-A or status window
- Witness=>select both, first, second or none, also via CTRL-B or status window
- Decimal=>select 0 to 6 decimal places (rounded to specified precision)
- Text=>(dim ht, note ht, dim fnt, not fnt, dim aln, not aln, not ang, chr asp)
  - Dim ht & not ht=>set new dimension or note heights (>.0005 units), also via status window as DH and NH
  - Dim fnt & not fnt=>select from 6 fonts for dimensions or notes, also via status window as DF and NF
  - Dim aln, not aln=>select from 9 positions for locating text
  - Not ang=>enter angle for text orientation, also via status window as RT
  - Chr asp=>aspect ratio of width to height of text characters, enter value from .01 to 100, also via status window as AS

Toler=>select angular or linear tolerance to be set, then select from tolerance menu (none, +/-, limit):
None=>no tolerance in dimension text
+/-=>positive and negative tolerances in dimension text, choose appropriate settings (pos tol, neg tol, 0 rep, dbl up):
Pos tol=>enter positive tolerance
Neg tol=>enter negative tolerance preceded by negative sign
0 rep=>select yes to suppress sign preceding a 0, or no
Dbl up=>allows both positive and negative sign on same line
Limit=>enter positive or negative tolerances for limit dimensioning

Standard=>(zero, dim aln)
Zero=>control display of leading and trailing zeros
Dim aln=>select yes to have dimensioning text aligned parallel to dimensioning direction

Units=>dimensions are multiplied by the appropriate conversion factor to dimension the drawing in desired units. Select the units in which you wish to dimension (inch, mm, feet, cm, yard, meter, user).

Ver dim=>select yes to have the "accept dimension" prompt after each dimension is placed, otherwise select no.

Using the detail menu options to edit dimensions, notes, and labels [detail-change] (txt att, txt pos, dim val, decimal, witness, arrows, toler, dim scl):
Txt att=>select attribute to change (font, height, not ang, aspect), then select done and dimensions, notes or labels to be changed
Txt pos=>select dim, note, or label to be moved, then position.
Dim val=>enter a new number for selected dimension
Decimal=>change precision of selected dimension
Witness=>change existing witness lines to both, first, second or none
Arrows=>change leaders or arrows of selected dimensions from inside to outside or vice versa
Toler=>change tolerance type (none, +/-, limit) & values (+ or - tol)
Dim scl=>enter new scale factor for selected dimensions

Using the detail menu options to update certain attributes of selected dimensions, notes, and labels to current settings [detail-update]:
Used to update text height and fonts on dimensions, notes and labels, and to update decimal places, dimension scale, trailing and leading zeros, and tolerance types and values on dimensions.

Using the detail menu options for crosshatching of sectional views of drawings [detail-x-hatch]:
Used to create crosshatching of enclosed area on sectional views. The area(s) to be x-hatched must be end to end around the area, and only line, arc, circle or spline type entities. X-hatching may be selected to be brick, steel, copper, alloys, aluminum, rubber, or marble. Enter the angle for the hatch lines, and the spacing distance between hatch lines, then select the enclosed areas.

CONTROL-VERIFY MENU OPTIONS

Using the control-verify menu options to verify attributes of entities [control-verify] (attrib, coord, dist, angle, perim, area/cn, moment):

- Attrib=>used to determine level, view in which created, color, font or line type, line width, pen#, group or subgroup name & group reference# of a selected entity
- Coor=>used to determine the coordinates of appropriate points defining the selected entity and the actual and projected line lengths if applicable
- Dist=>used to verify three kinds of distances
  - 2 pos=>distance between two position
  - Pos+ent=>minimum distance between a position and a line or curve
  - 2 lines=>minimum distance between two selected lines
- Angle=>verify angle between two selected intersecting or potentially intersecting lines
- Perim=>calculates and displays the actual and projected length of a selected entity or series of connected entities.
- Area/cn=>used to verify the area of an enclosed figure and the coordinates of its centroid
- Moment=>the polar moment of inertia of an enclosed area with respect to a specified axis is calculated and displayed

ASSIGN EXERCISES 6.1-8

CHAPTER 7 - TRANSLATING, ROTATING, AND MIRRORING:

TRANSFORMING EXISTING ENTITIES USING THE X-FORM MENU

Definitions of translate, rotate, scale, mirror
Translate=>new location with same orientation (not rotated)
Rotate=>new location rotated in plane of screen about a position
Scale=>enlarged (>1) or reduced (<1) by a factor about a position
Mirror=>new location mirrored about the 2D or 3D axis indicated

Descriptions of move, copy, join options used with the x-form menu
Move=>draw entities at new position, delete entities at old position
Copy=>make a copy of entities at new position
Join=>make a copy of entities at new position and connect to entities at old position at corresponding ends or points
NOTE: All of the x-form menu options are followed by the move, copy or join options. Copy and join options will always prompt for the number of copies with all of the x-form menu options except for the mirror option.

X-FORM MENU

Translations using the trans-r menu option [x-form-trans-r]:
Choose either move, copy, or join, select entities, enter number of copies (for copy or join only), then input increments (delta) for the translation in x,y,x or xv,yv,zv depending on which coordinate system (world=>dx,dy,dz or view=>dxv,dyv,dzv) is currently set

Translations using the trans-a menu option [x-form-trans-a]:
Choose either move, copy, or join, select entities, enter number of copies (for copy or join only), indicate base position, and then indicate the new base position

Rotations using the 2D rotate menu option [x-form-2d rot]:
Choose either move, copy, or join, select entities, enter number of copies (for copy or join only), indicate position of rotation origin (axis of rotation perpendicular to the screen), and then enter rotation angle

Scaling using the scale menu option [x-form-scale]:
Choose either move, copy, or join, select entities, enter number of copies (for copy or join only), indicate scaling origin, and then enter the scale factor desired

Mirroring using the mirror menu option [x-form-mirror]:
Choose either move, copy, or join, select entities, indicate two points that define the mirroring axis

ASSIGN EXERCISES 7.1-5

Summary of topics covered in chapter 7:
- Definitions of translate, rotate, scale and mirror
- Descriptions of move, copy, and join
- Use of the x-form menu options:
  - trans-r, trans-a, 2d rotate, scale, and mirror

CHAPTER 8 - CREATING THREE-DIMENSIONAL DRAWINGS:

Review tutorial of block with hole:
- Create a 3" square in top view, extrude 2 inches down to create block
- Create 1" diameter circles at depths of 0 and -2"
- Save part as BOX
- Delete hidden lines from view 7
- Create-line-mesh with 20 segments between circles with no cross lines
- Delete lower circle and trim mesh lines
- Save view 7 as BOX7.ptn
- Save view 1 as BOX1.ptn
- Save view 2 as BOX2.ptn
- Save view 5 as BOX5.ptn
- Create a 4 view drawing from the pattern files
- Switch to level 2 to dimension drawing and save as BOX4V

ASSIGN EXERCISES 8.1-4

Summary of topics covered in chapter 8:
- Creating a 3D wireframe model
- Creating appropriate pattern files for a 4 view drawing
- Retrieving pattern files for a 4 view drawing
- Dimensioning a 4 view drawing

CHAPTER 9 - SETTING CONSTRUCTION MODE AND CHOOSING A COORDINATE SYSTEM:

2D mode => depth is generally the current working depth unless key-in positioning is used

3D mode => positioning using cursor is current working depth, positioning using an entity is defined by depth of entity, and key-in positioning uses depth entered

Positioning exercises using 2D vs. 3D construction modes

Review view coordinates and world coordinates

Tranformation exercises with view vs. world coordinates

ASSIGN EXERCISES 9.1-5

Summary of topics covered in chapter 9:
- Distinction between 2D vs. 3D construction switch settings
- Utilization of world and view coordinates in the creation of 3D drawings

CHAPTER 10 - CREATING ASSEMBLY DRAWINGS:

Tutorial 1 => create an exploded assembly drawing of the ranch house and floorplan

Tutorial 2 => created an assembly and exploded assembly of two mechanical parts

ASSIGN EXERCISES 10.1-3

Summary of topics covered in chapter 10:
   Creation of assembly drawings

CHAPTER 11 - DEFINING VIEWS:

Defining views utilizing the view menu options [display-view-define] (rotate, 3-pts):

- Rotate=>used to enter desired rotation of the displayed view to create a new view (top in, top out, right in, right out, cw, ccw, done):
  - Top in/out=>input desired rotation about xv axis
  - Right in/out=>input desired rotation about the yv axis
  - Cw/ccw=>input desired rotation about the zv axis
  - Done=>choose when all rotations are specified to define new view

- 3-pts=>position 3 pts to define the view (use with switch on 3D const)
  - pt1=>origin for new xy view plane
  - pt2=>pt on new xv axis
  - pt3=>pt on new xy view plane (noncollinear with first two pts)

Exercise to view ranch house with rotate option

Tutorial for angled bracket utilizing auxiliary view

ASSIGN EXERCISES 11.1-4

Summary of topics covered in chapter 11:

- Use of the view menu option to define new views
- Utilization of defining views for creating entities on inclined or oblique surfaces
- Creating auxiliary view drawings

CHAPTER 12 - PUTTING IT ALL TOGETHER:

WIREFRAMES OF REVOLUTION

Tutorial to create an inner tube shaped wireframe model

Tutorial to create a 4 view drawing of a bracket

ASSIGN EXERCISES 12.1-6

Summary of topics covered in chapter 12:
- Creation of a wireframe of revolution
- Techniques for more complicated 3D models

SECTION V-j - PILOT PROJECT: CORROSION - PROOF BOAT TRAILER

CORROSION - PROOF BOAT TRAILER

General Directions: This project will provide you with the same manufacturing experiences you would have in industry. It will provide you a change to: cut composite/advanced materials by machining techniques; form aluminum alloys to proper shapes; assemble composites with aluminum alloys with adhesives and fasteners; TIG weld aluminum alloys; and apply finishes which would be suitable in a marine/saltwater environment. Before starting you should look at the bill of materials, specifications, drawings, and plan of procedure. Doing this will permit you to construct a better project in less time should you think of improvements that could be made to the design while working on the projects, you will be encouraged to use CAD and submit your ideas for a "redesign."

Specifications: Standard fiberglass reinforced structurals (I-beams, etc), regular pultruded fiberglass-reinforced parts, aluminum alloy material, and purchased sub-assemblies (a hitch, etc.) will be used on this trailer. Just as in industry, where it is more economically feasible, certain parts are purchased. The fiberglass reinforced plastic (frp) structurals and materials will be used throughout the frame where possible. Since you have already been exposed to machining techniques on other projects, you will need to select the proper machine to use for all cutting and grinding operations. Remember to use the correct feed and speed which will give you smooth edges. Where necessary, certain frp members may also need minor changes (grinders, etc.) to make them fit into the purchased parts. To ensure the long life of all frp members, all such cuts and ground surfaces must be sealed with the resin used in the frame before assembly occurs. A urethane finish will be applied to the completed frp frame to enhance its weathering characteristics. It may be colored if needed.

All angular joints (those more than 90 degrees) will be assembled using aluminum plates which have been cut to size (see drawing) and formed to the proper angle (see drawing). They should be wire brushed with a circular wire brush and portable electric drill to create a circular brushed finish. After finishing them, they should be joined to the frp using bolts and adhesives.

During frame assembly all parts must be fastened with adhesives and bolts. Flat washers should be used with all bolts. The bolts should be galvanized.

The purchased parts may be assembled as is, or painted as necessary to complement the color scheme chosen.

Ensure that all lighting and brake assemblies meet Pennsylvania Department of Transportation codes.

Plan of Procedure

____ 1. Read the project sheet before beginning and use reference books as necessary.

____ 2. Complete a bill of materials.

____ 3. Ask any questions that arise from your reading and obtain instructor approval before proceeding.

When Using FRP

____ 4. Obtain and cut FRP to rough size.
Cantion: Wear goggles and a respirator if necessary during all cutting operations.
Be sure to use proper clamping procedures.

____ 5. As necessary, make second more precise cuts to obtain final dimensions and angles.

____ 6. Match drill all FRP parts during prefitting.

____ 7. Prepare FRP surfaces for adhesives and finishes.

____ 8. Apply the same resin as used in your FRP to all cut edges.

When using Alluminum Alloys

____ 9. Cut material to finished size.
Caution: Use the proper dark green goggles when plasma-cutting.

____10. Machine special cuts (see drawings).

____11. Bend parts as necessary, to the proper angle indicated in the drawing.

____12. Weld parts together as necessary (see drawing).

____13. Apply a circular brushed finish to the outside surfaces with a circular wire brush and a portable electric drill.

____14. Clamp and match drill all aluminum parts during prefitting.

When Working with a Small Number of Students

____15. Fabricate trailer frame assembly.

____16. Finish frame with desired color of urethane.

____17. Paint axle/wheel assembly desired color, if necessary.

_____18. Mount axle/wheel assembly to trailer frame.

_____19. Fabricate hitch brachet.

_____20. Fabricate winch stand.

_____21. Paint hitch and winch desired color.

_____22. Fabricate fender assembly.

_____23. Paint as desired.

_____24. Mount fender assembly.

_____25. Mount rollers, cradle and winch.

_____26. Mount tail lights and wiring harness.

_____27. Check all components for proper operation.

When Working with Larger Numbers of Students

_____28. Cut and fabricate all sub-assemblies similtaneously.

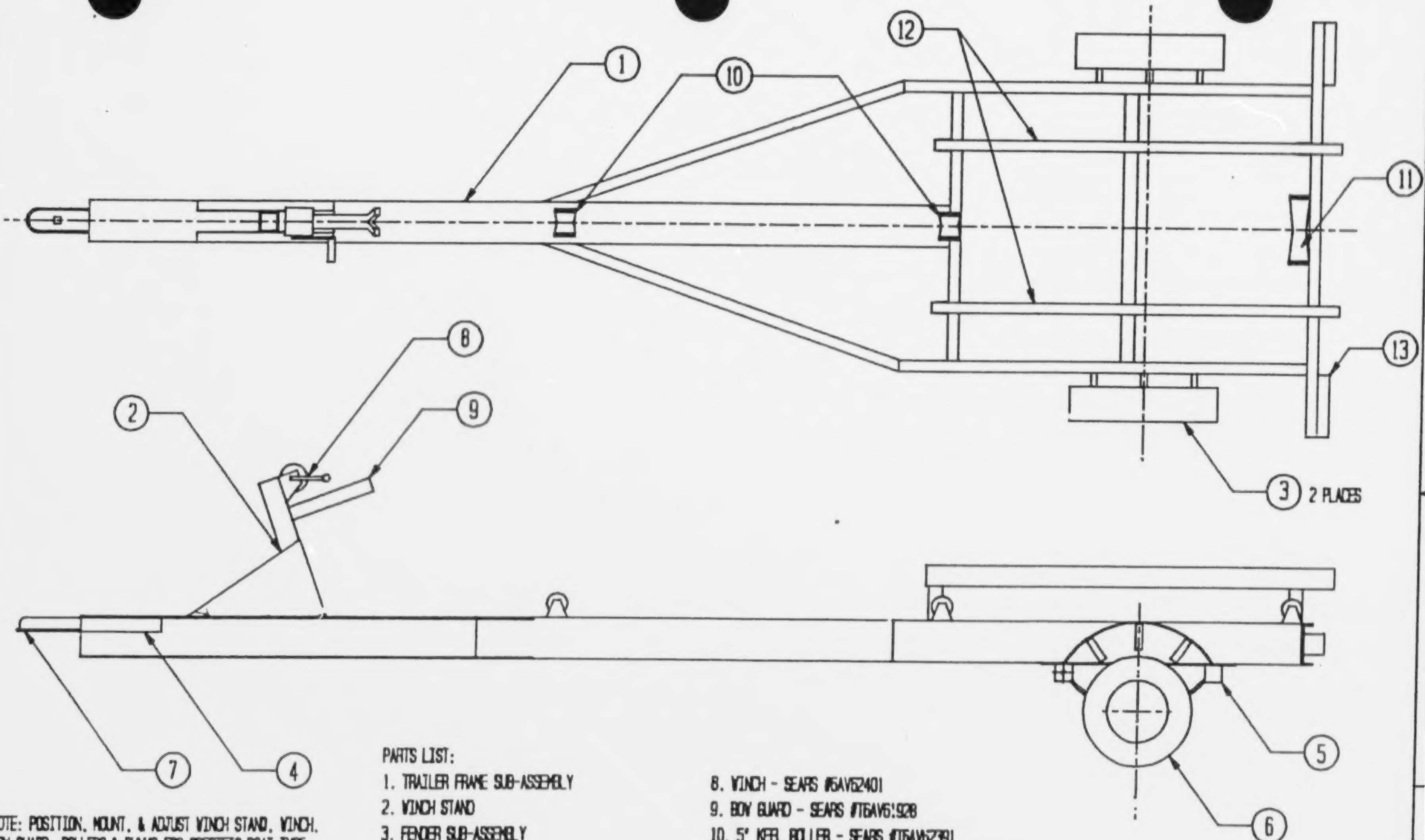
_____29. Finish with desired color of urethane for FRP and proper paint for aluminum.

_____30. Assemble frame and wheel/axle assembly.

_____31. Mount other sub-assemblies.

_____32. Mount wiring harness.

_____33. Check all components for proper operations.



NOTE: POSITION, MOUNT, & ADJUST WINCH STAND, WINCH, BOW GUARD, ROLLERS & BUNKS FOR SPECIFIC BOAT TYPE.

ALL THREADED FASTENERS CONSIST OF BOLT, NUT, 2 WASHERS, AND LOCKWASHER.

ALL THREADED FASTENERS ARE .375" DIA. EXCEPT FOR FENDERS (.250" DIA.) & BALL COUPLER (.50" DIA.)

PARTS LIST:

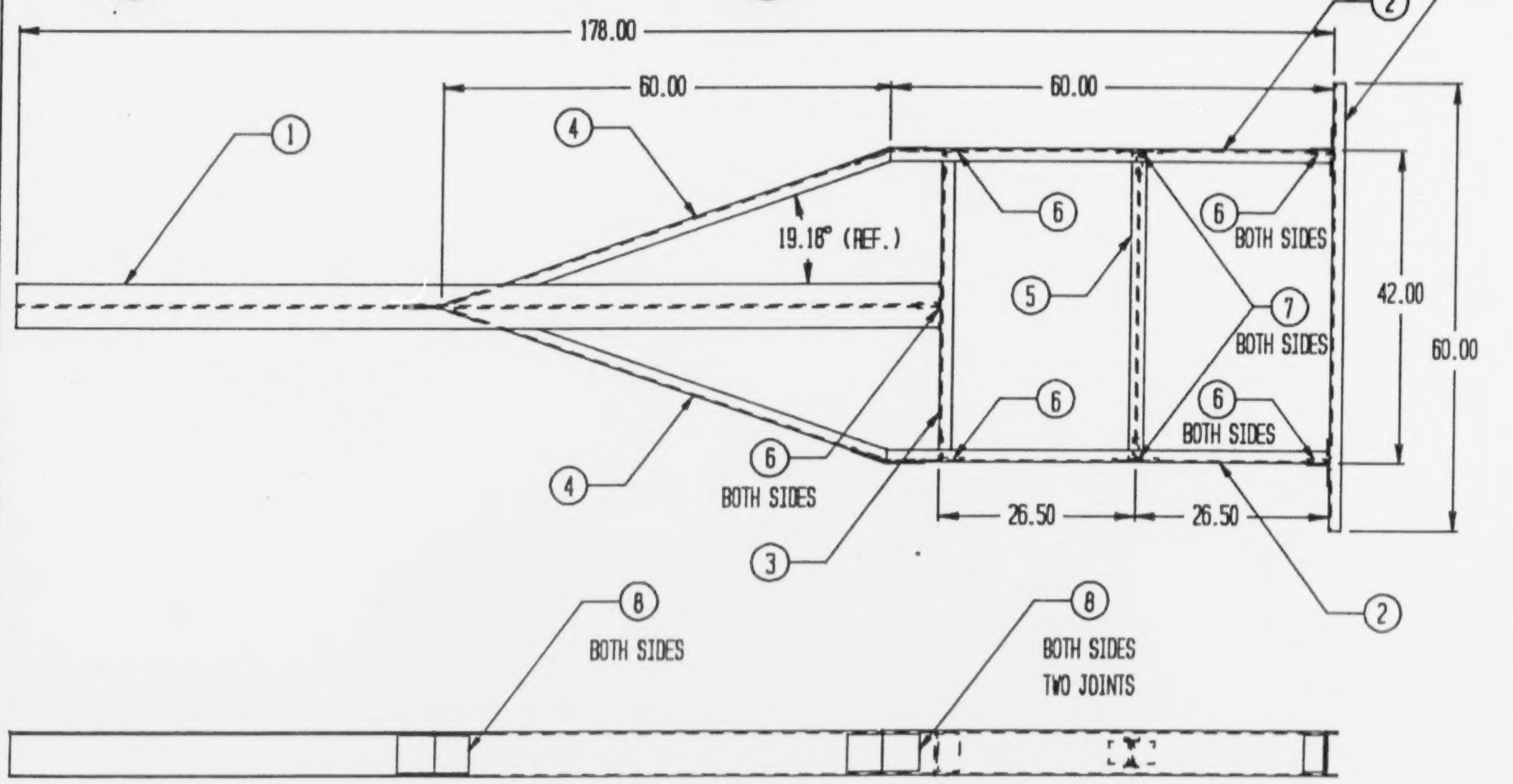
1. TRAILER FRAME SUB-ASSEMBLY
2. WINCH STAND
3. FENDER SUB-ASSEMBLY
4. HITCH BRACKET
5. SPRING BRACKET
6. TRAILER AXLE KIT & TIRE/WHEEL ASSEMBLY
   - J.C.WHITNEY #81-9265B & #62-1499Y
7. BALL COUPLER (1.875") - SEARS #28AV22217
8. WINCH - SEARS #6AV62401
9. BOW GUARD - SEARS #T6AV61928
10. 5" KEEL ROLLER - SEARS #T6AV62391
11. 10" KEEL CENTERING ROLLER - SEARS #T6AV62366
12. 5' LONG 2X4" ON BUNK SUPPORT BRACKETS - SEARS #6AV62399
13. SUBMERSIBLE LIGHT KIT - SEARS #T6AV61852

BEDFORD-EVERETT AREA VOCATIONAL-TECHNICAL SCHOOL

BOAT TRAILER ASSEMBLY

SIZE C	DATE [illegible]	DWG NO. 1001	REV 0
SCALE 1/10=1.0	DRAWN BY T.J.B./G.H.B.	SHEET 1 OF 10	

BEST COPY AVAILABLE


178.00
60.00
60.00
①
②
②
②
②
③
④
④
⑤
⑥
⑥
⑥
⑥
⑥
⑦
⑧
⑧
19.18° (REF.)
BOTH SIDES
BOTH SIDES
BOTH SIDES
BOTH SIDES
42.00
60.00
26.50
26.50
BOTH SIDES
BOTH SIDES
TWO JOINTS

PARTS LIST:
1. ONE 6X6X.25 WIDE FLANGE I-BEAM 125 LONG FRP
2. THREE 6X1.62X.25 CHANNEL 60 LONG FRP
3. ONE 6X1.62X.25 CHANNEL 41.5 LONG FRP
4. TWO 6X1.62X.25 CHANNEL 62.5 LONG FRP
5. ONE 4X2X.25 I-BEAM 41.5 LONG FRP
6. EIGHT 3X.25 EQUAL LEG ANGLE 5 LONG FRP
7. FOUR 3X.25 EQUAL LEG ANGLE 3 LONG FRP
8. SIX 10X5X.125 ALUMINUM PLATES

NOTE: ALL PARTS 6 AND 7 ARE BONDED AND BOLTED TO FRAME

BEDFORD-EVERETT AREA VOCATIONAL-TECHNICAL SCHOOL
TRAILER FRAME SUB-ASSEMBLY
SIZE C DATE 8/24/88 DWG NO. 1001 REV 0
SCALE 1/10=1.0 DRAWN BY T.J.R./G.H.B. SHEET 2 OF 10

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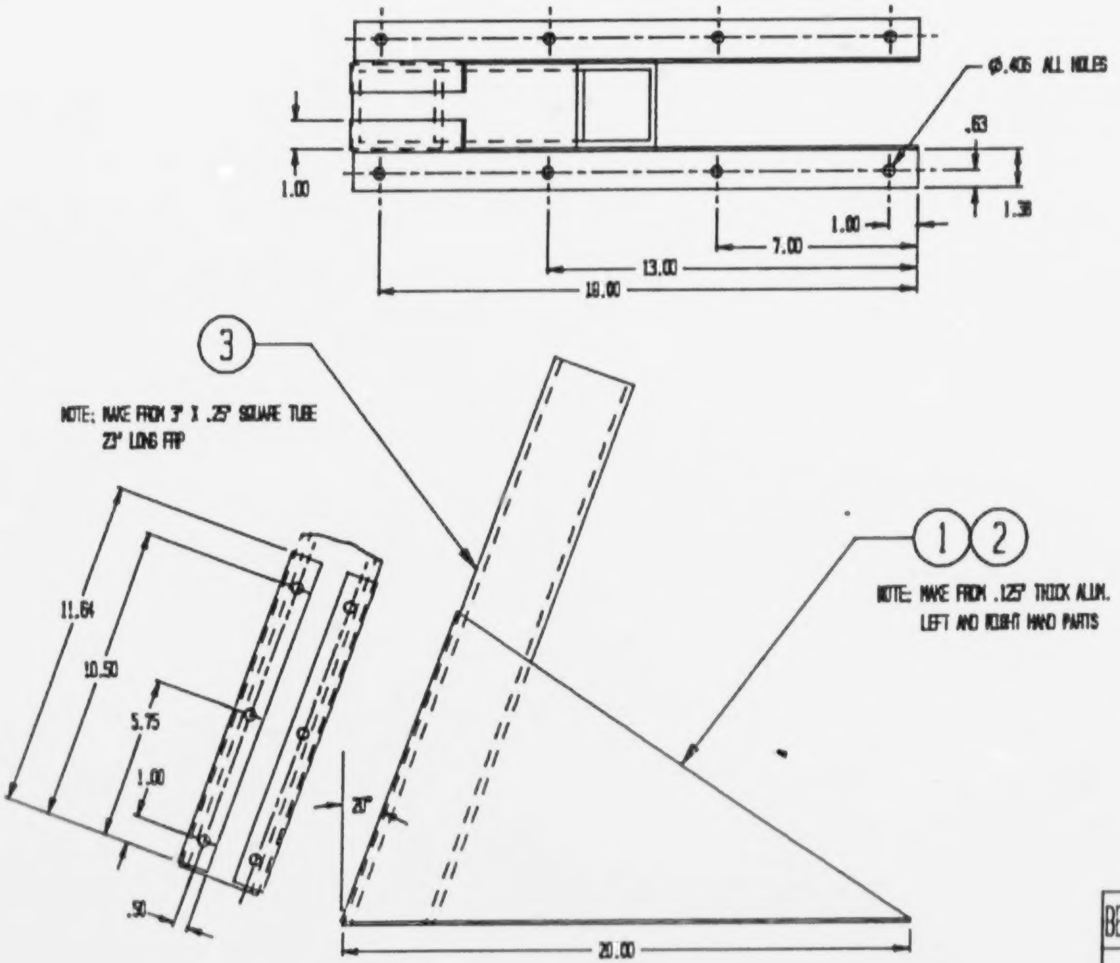
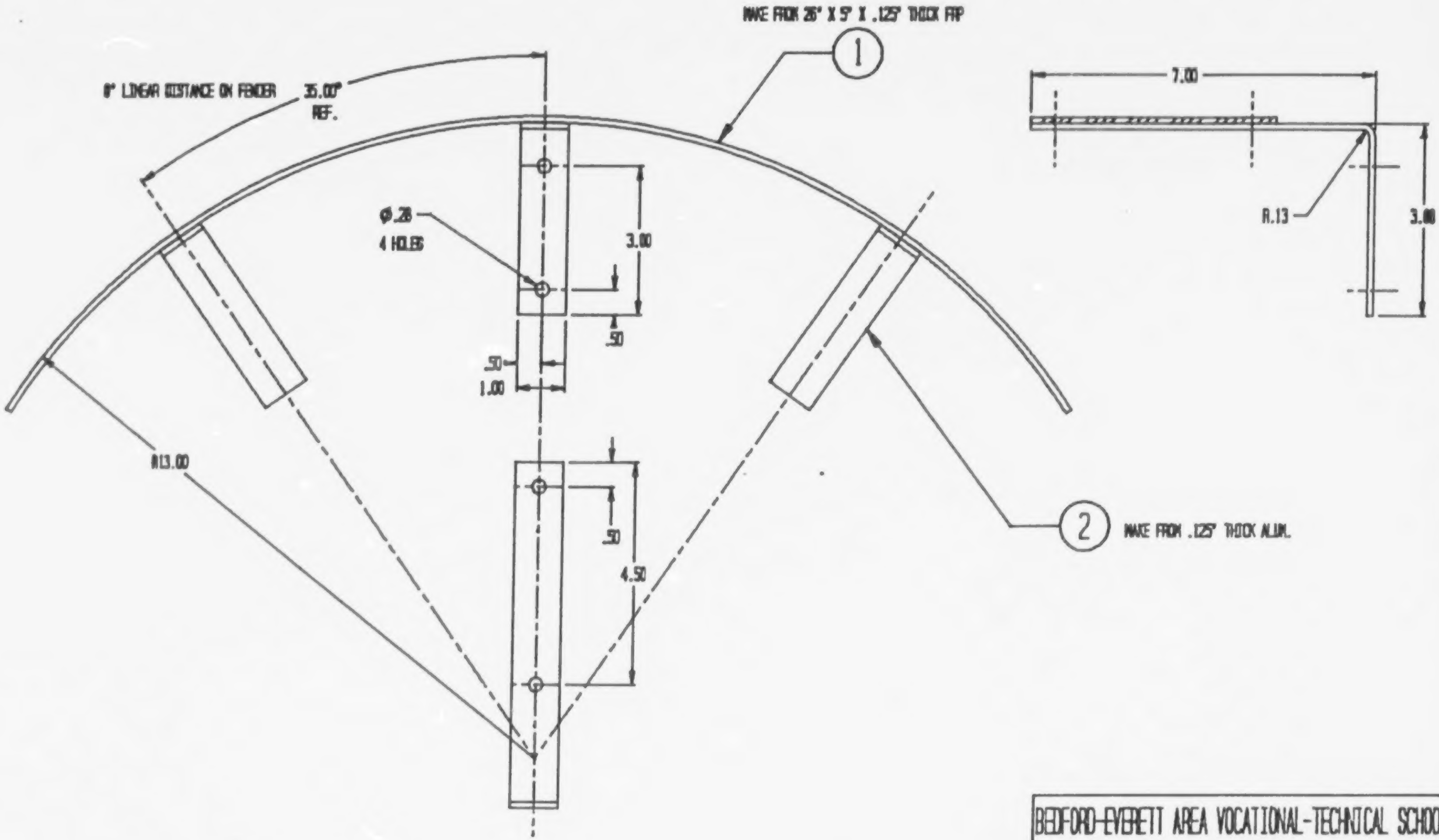

Ø.406 ALL HOLES
.63
1.00
1.38
1.00
7.00
13.00
19.00
3
NOTE: MAKE FROM 3" X .25" SQUARE TUBE
23" LONG FRP
1
2
NOTE: MAKE FROM .125" THICK ALUM.
LEFT AND RIGHT HAND PARTS
11.64
10.50
5.75
1.00
.50
20°
20.00

BEDFORD-EVERETT AREA VOCATIONAL-TECHNICAL SCHOOL			
WINCH STAND			
SIZE B	DATE 6/24/88	DWG NO. 1001	REV 0
SCALE 1/4=1.0	DRAWN BY T.J.M/S.H.O.	SHEET 3 OF 10	

BEST COPY AVAILABLE

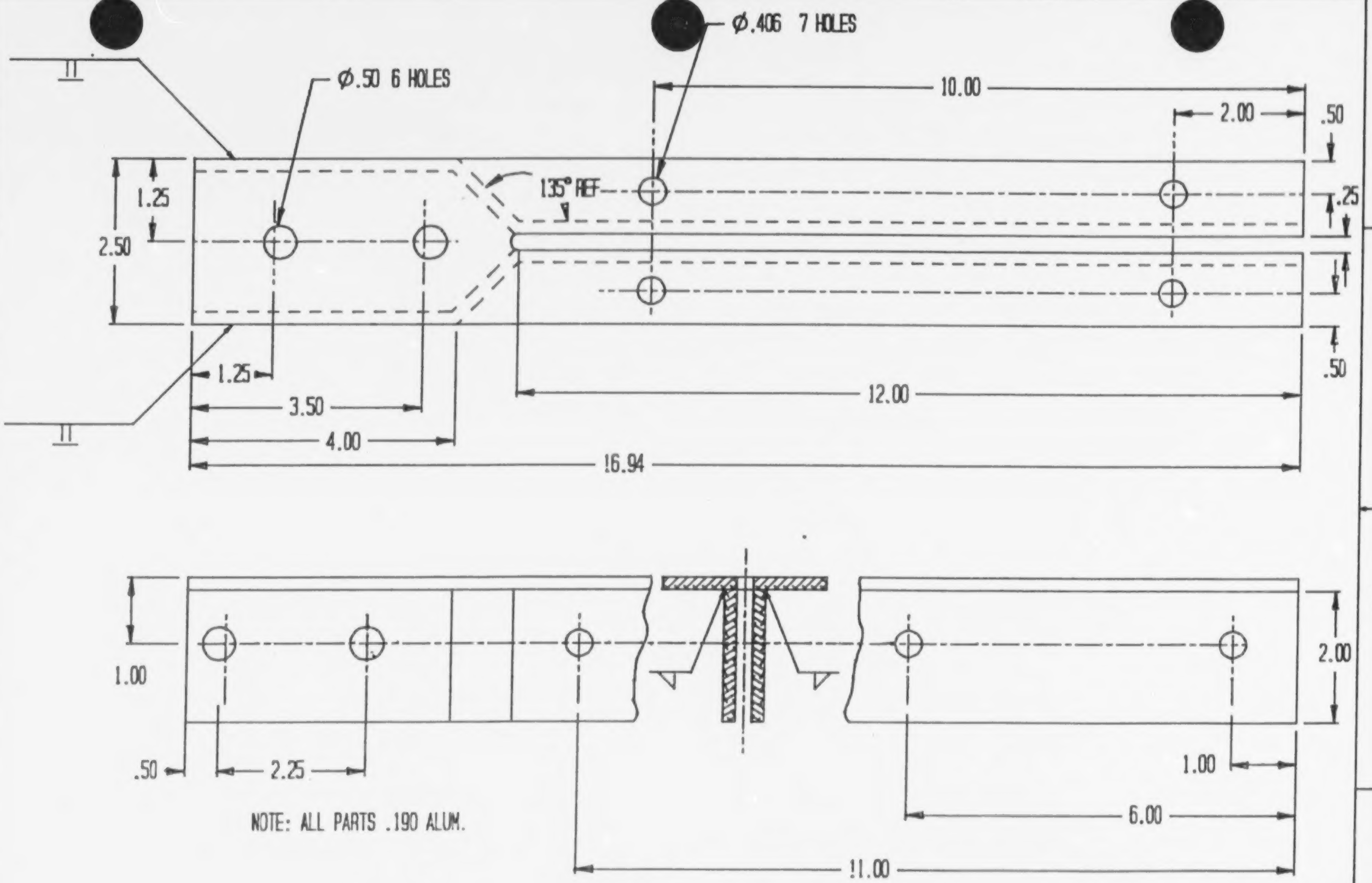

MAKE FROM 26" X 5" X .125" THICK FRP
1
8" LINEAR DISTANCE ON FENDER
35.00°
REF.
Ø.28
4 HOLES
3.00
.50
.50
1.00
R13.00
.50
4.50
2
MAKE FROM .125" THICK ALUM.
7.00
R.13
3.00

BEDFORD-EVERETT AREA VOCATIONAL-TECHNICAL SCHOOL

FENDER SUB-ASSEMBLY

SIZE B	DATE 6/24/88	DWG NO. 1001	REV 0
SCALE 1/2=1.0	DRAWN BY T.J.M./S.H.O.	SHEET 4 OF 10	

BEST COPY AVAILABLE

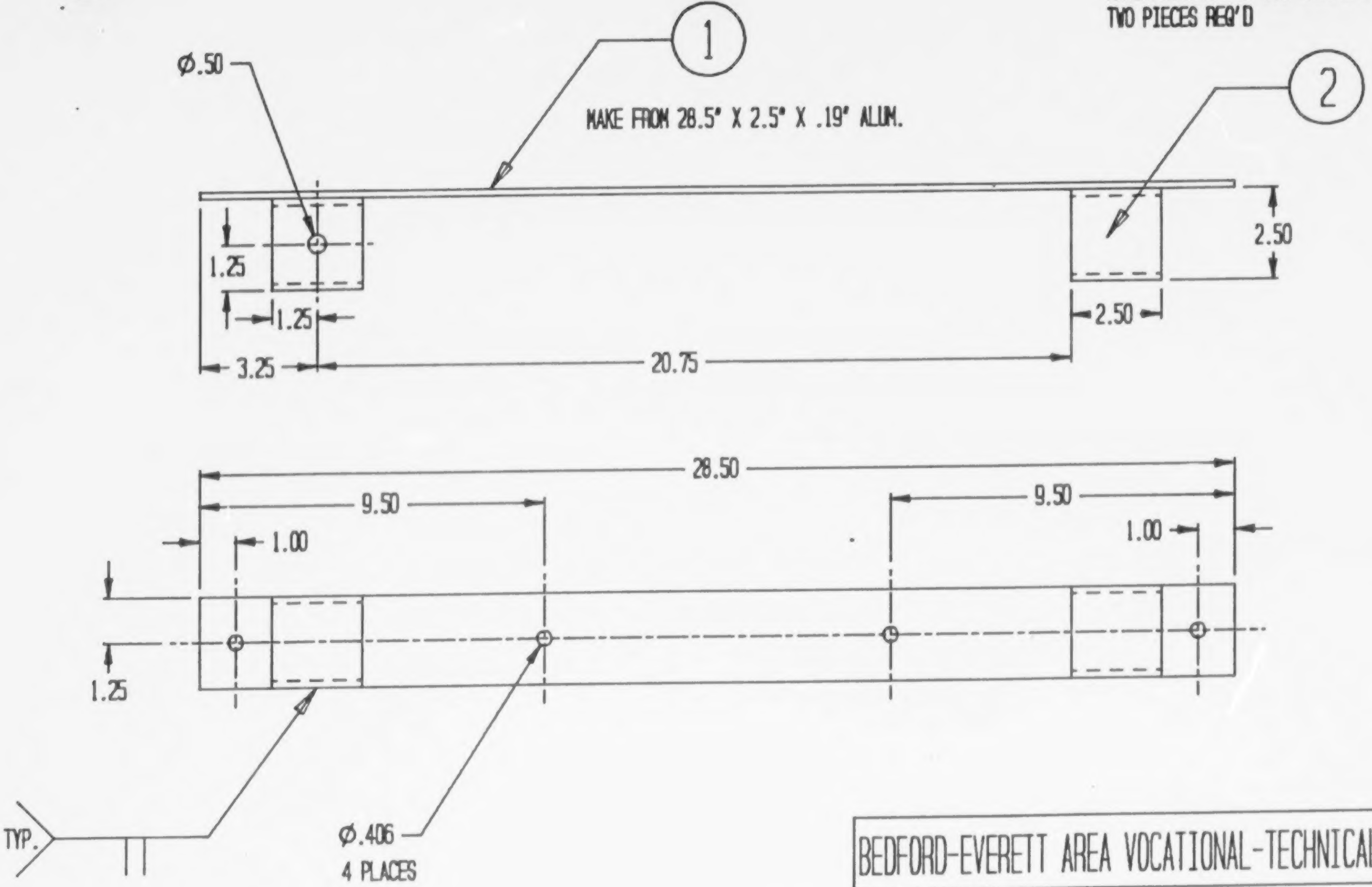

Ø.50 6 HOLES
Ø.406 7 HOLES
10.00
2.00
.50
135° REF
1.25
2.50
.25
.50
1.25
3.50
4.00
12.00
16.94
1.00
2.00
.50
2.25
1.00
6.00
11.00

NOTE: ALL PARTS .190 ALUM.

BEST COPY AVAILABLE

BEDFORD-EVERETT AREA VOCATIONAL-TECHNICAL SCHOOL			
HITCH BRACKET			
SIZE C	DATE 8/24/88	DWG NO. 1001	REV 0
SCALE FULL	DRAWN BY [illegible]	SHEET 5 OF 10	

MAKE FROM 2.5" x .1[illegible] ALUM. SQ. TUBING
TWO PIECES REQ'D

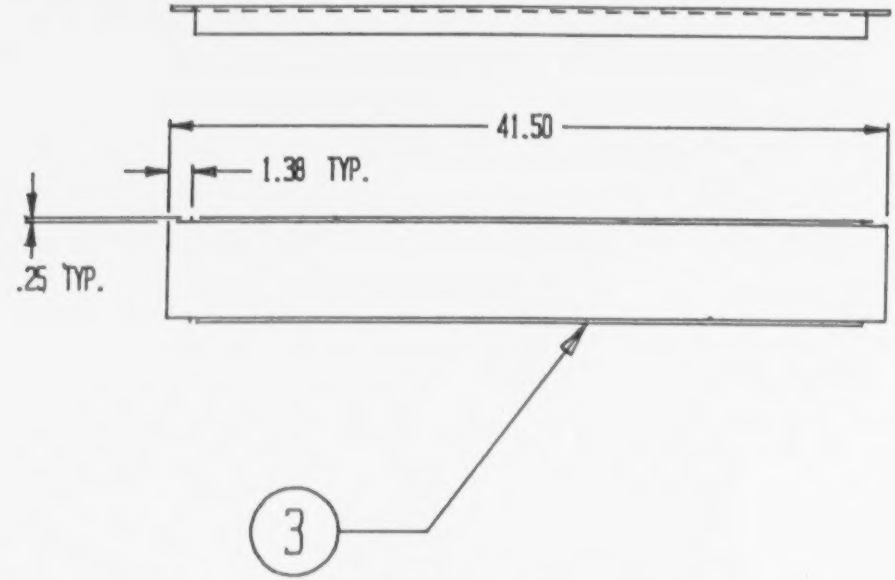

1
Ø.50
MAKE FROM 28.5" X 2.5" X .19" ALUM.
2
2.50
1.25
1.25
2.50
3.25
20.75
28.50
9.50
9.50
1.00
1.00
1.25
TYP.
Ø.406
4 PLACES

BEDFORD-EVERETT AREA VOCATIONAL-TECHNICAL SCHOOL

SPRING BRACKET

SIZE A	DATE 6/24/88	DWG NO. 1001	REV D
SCALE 1/4=1.0	DRAWN BY S.H.D./T.J.M	SHEET 6 OF 10	

BEST COPY AVAILABLE



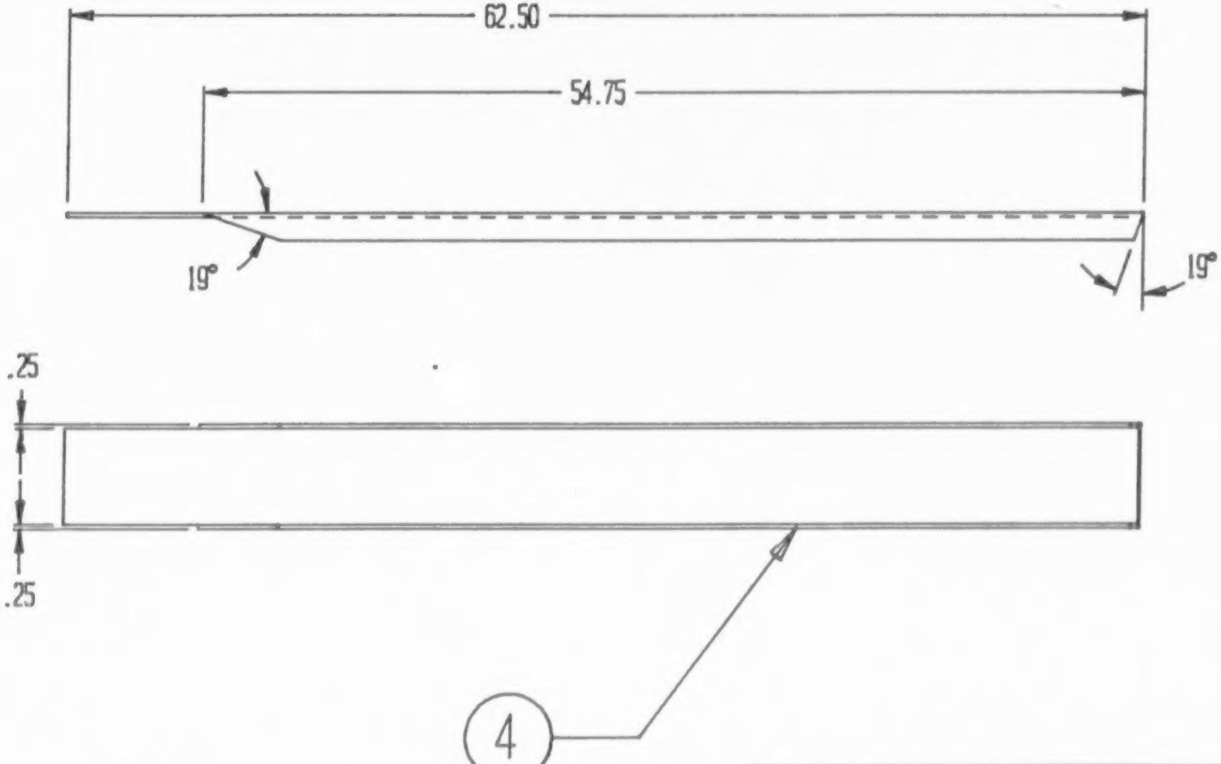
REF. TRAILER FRAME SUB-ASSEMBLY DRAWING

MAKE FROM 6" X 1.62" X .25" FRP CHANNEL

BEDFORD-EVERETT AREA VOCATIONAL-TECHNICAL SCHOOL

CROSS CHANNEL

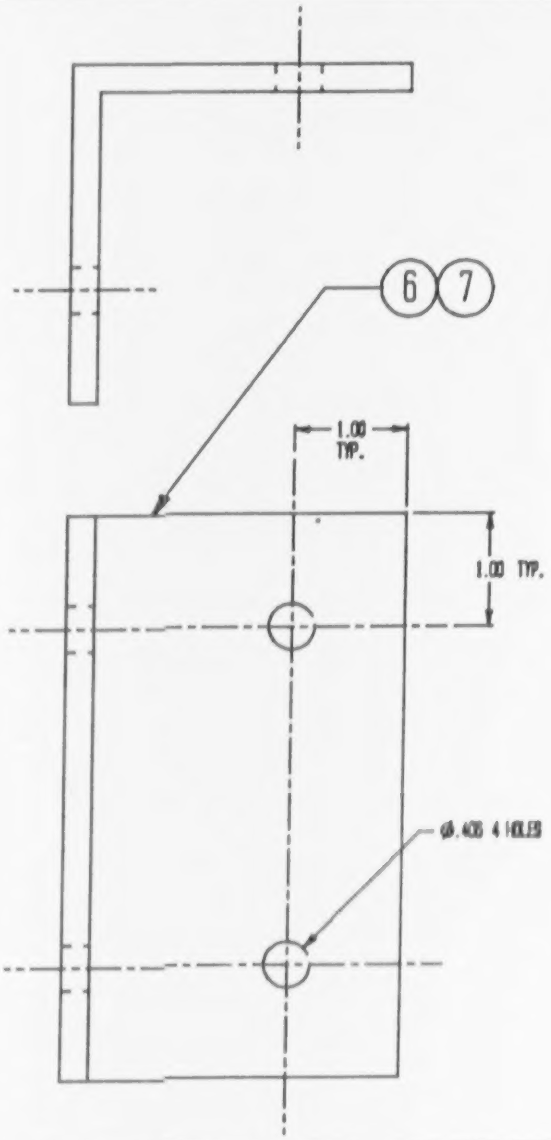
SIZE A	DATE 6/24/88	DWG NO. 1001	REV 0
SCALE 1/10=1.0	DRAWN BY T.J.M./S.H.O.	SHEET 7 OF 10	



REF. TRAILER FRAME SUB-ASSEMBLY DRAWING

MAKE FROM 6" X 1.62" X .25" FRP CHANNEL

BEDFORD-EVERETT AREA VOCATIONAL-TECHNICAL SCHOOL			
FRONT CHANNEL			
SIZE A	DATE 6/24/88	DWG NO. 1001	REV 0
SCALE 1/10=1.0	DRAWN BY T.J.M./S.H.O.	SHEET 8 OF 10	



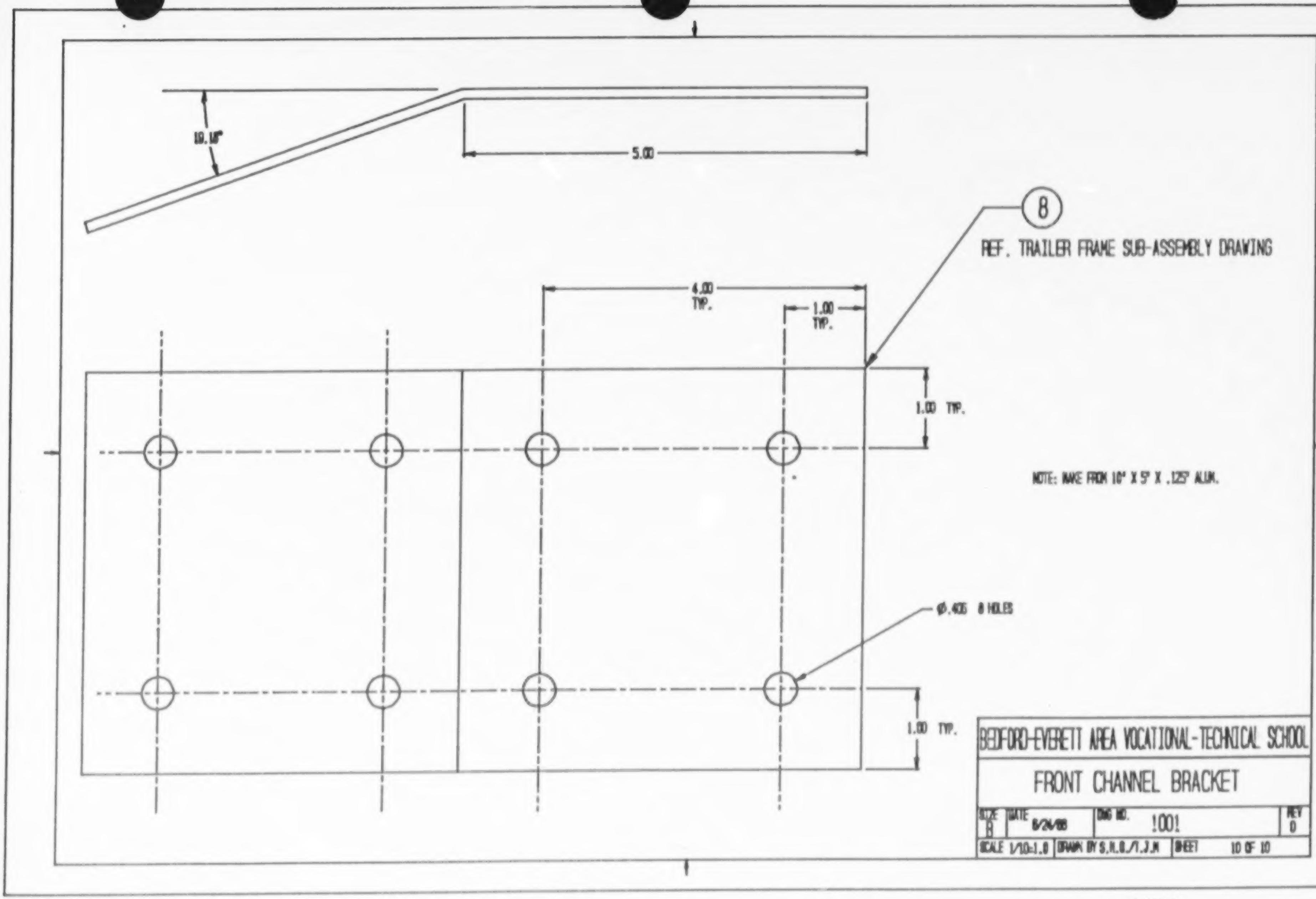
⑥ 5" LONG REF. TRAILER FRAME SUB-ASSEMBLY DRAWING

⑦ 3" LONG REF. TRAILER FRAME SUB-ASSEMBLY DRAWING

MAKE FROM 3" X .25" EQUAL LEG ANGLE FRP

BEDFORD-EVERETT AREA VOCATIONAL-TECHNICAL SCHOOL			
ANGLE BRACKET			
SIZE B	DATE 8/24/89	DWG NO. 1001	REV 0
SCALE FULL	DRAWN BY S.H.O./T.J.N	SHEET 9 OF 10	

BEST COPY AVAILABLE


18.18°
5.00
8
REF. TRAILER FRAME SUB-ASSEMBLY DRAWING
4.00 TYP.
1.00 TYP.
1.00 TYP.
NOTE: MAKE FROM 10" X 5" X .125" ALUM.
Ø.406 8 HOLES
1.00 TYP.

BEDFORD-EVERETT AREA VOCATIONAL-TECHNICAL SCHOOL

FRONT CHANNEL BRACKET

SIZE B
DATE 6/24/88
DWG NO. 1001
REV 0
SCALE 1/10=1.0
DRAWN BY S.H.G./T.J.M
SHEET 10 OF 10

SECTION V-k - RESEARCH

Research was done to establish a list of over 40 companies in the Bedford and adjoining counties which either manufactured or processed parts utilizing advanced materials replacing metals or advanced metals. Searching through this data base indicated that the majority (over 20) of these companies either make plastic or composite parts or make tooling for manufacturing these parts. Other companies manufactured ceramic, rubber, glass, and powdered metal products. Manufacturing with plastics and composites and the welding and joining of these materials appear to be a good starting point since the Bedford-Everett AVTS already has a fabrication program for metals.

Several plant visits were conducted by Steve Orner and Tom Malmgren to become familiar with the products and manufacturing processes of several of the local companies which make plastic and composite products. (Gilmour Manufacturing Co., Green Garden Inc., and Bedford Reinforced Plastics)

Both Gilmour and Green Garden produce thermoplastic and zinc die cast parts, primarily for lawn and garden products. (i.e. garden hose mending parts, spray nozzles, siphons, sprayers, etc.) Almost all of their products are manufactured and assembled on-site. Very few parts used in the assembly of their finished products are purchased from outside sources. Gilmour is a very progressive company with many automated and robotized operations, while Green Garden is manual labor oriented. Both companies have experienced rapid growth over the past 5 years. Employment opportunities for vo-tech graduates would be limited since employee turnover is virtually nonexistent, and openings occur only as a result of expansion of the companies.

Bedford Reinforced Plastics and Creative Pultrusions are companies in the local area that produce polymer composite pultrusions used for a variety of applications from structural fabrications to non-conducting electrical parts to corrosion resistant products. During the visit to Bedford Reinforced Plastics, they observed workers fabricating and assembling parts for a customer. It was mentioned that many of their customers wanted finished fabrications made from the reinforced fiberglass parts and found it difficult to find companies willing to produce the fabrications. Although they are primarily in the business of producing the raw materials, they have found it necessary to also be in the fabrication business. This is an excellent opportunity machining of reinforced fiberglass to contract work which could easily be done in a small business or job shop type environment. This need could readily be met by the Advanced Materials and Advanced Metals curriculum.

It was then decided that the use of reinforced fiberglass pultrusions for the purpose of designing, fabricating, and producing finished products was a very real need in the local area and would be an excellent choice as a starting point for the new curriculum. The special safety, tooling, machining, properties/characteristics, joining and fabricating considerations of using these materials are not being taught anywhere at the vo-tech level. Many techniques used by manufacturers are not documented or considered proprietary information. The development of a curriculum in this are should prove to be a worthwhile task that should give readily marketable skills to vo-tech graduates. Furthermore, the use of current Computer-Aided-Manufacturing (CAM) techniques can be readily used in the preparation of parts for fabrication, which will also enhance the training skills of students in this curriculum.

Resource materials for use in developing a curriculum have been located and collected. These materials will be the basis for the vo-tech instructors to begin writing the curriculum materials.

Research was done to identify four courses in the Engineering Technology curriculum that would be appropriate to include in an articulation agreement between UPJ and BEAVTS. Work was completed on a rough draft of the agreement.

Another area of work was determining the upgrading requirements of the current CAD workstation and to identify, purchase and install a math coprocessor so the CAD and CAM software would operate properly. Together, Steve Orner and Tom Malmgren worked with the CAD and CAM software. After becoming familiar with the basic operation of the CAM software that is use to run their CNC mill, Steve and Tom spent time working with the machines to become reasonable knowledgeable in its operation. In April, Steve and Tom demonstrated the CAD and CAM software, along with the operation of the mill and plotter to the vo-tech joint operating committee at the monthly board meeting.

43 [illegible] by [illegible]

1

Company: Cannondale Corp.
Address: RD6 Friendship Rd. PO Box 500
City: Bedford State: PA Zip: 15522 County: Bedford
Telephone: 814 623-9073
Products: Aluminum bicycles

Company: U S Sports
Address: Industrial Park
City: Huntington State: PA Zip: 16652 County: Huntington
Telephone: 814 643-2222
Products: Canvas and rubber footwear

Company: Maryland Refractories Co.
Address: PO Box 355
City: Alexandria State: PA Zip: 16611 County: Huntington
Telephone: 814 669-4452
Products: Ceramic clay refractories

Company: General Refractories
Address: Bedford St.
City: Claysburg State: PA Zip: 16625 County: Blair
Telephone: 814 239-2121
Products: Ceramic coke oven brick

Company: Blair Clay Products
Address: S 10th Ave. & 34th St. PO Box 872
City: Altoona State: PA Zip: 16603 County: Blair
Telephone: 814 943-6132
Products: Ceramic fire ladle brick

Company: Allied Corp.
Address: PO Drawer 179
City: Mount Union State: PA Zip: 17066 County: Huntington
Telephone: 814 542-2551
Products: Ceramic non-clay refractories

Company: Industrial Refractories Inc.
Address: 101 Swank Ct.
City: Johnstown State: PA Zip: 15901 County: Cambria
Telephone: 814 535-5592
Products: Ceramic refractory, nozzles, sleeves, brick

Company: Fry Metal Inc.
Address: 6th Ave. & 41st St.
City: Altoona State: PA Zip: 16602 County: Blair
Telephone: 814 946-1611
Products: Extruded metals, and lead products

Company: Creative Pultrusions Inc.
Address: Pleasantville Industrial Park
City: Alum Bank State: PA Zip: 15521 County: Bedford
Telephone: 814 839-4186
Products: Fiberglass products

Company: Bedford Reinforced Plastics
Address: RD2 Box 412
City: Bedford State: PA Zip: 15522 County: Bedford
Telephone: 814 623-9041
Products: Fiberglass products

Company: F R P Fabrication
Address: Box 388
City: Huntington State: PA Zip: 16652 County: Huntington

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Products: Fiberglass and nonmetallic mineral products

Company: Owens-Corning Fiberglass Corp.
Address: 12th & Susquehanna Ave. PO Box 382
City: Huntington State: PA Zip: 16652 County: Huntington
Telephone: 814 643-3240
Products: Fiberglass and glass yarns, fiberglass tanks

Company: Reihart, N. E. & Sons
Address: 821 Juniata Ave.
City: Huntington State: PA Zip: 16652 County: Huntington
Telephone: 814 643-0541
Products: Fiberglass tank parts

Company: Owens-Corning Fiberglas Corp.
Address: RD1 PO Box 299
City: Mount Union State: PA Zip: 17066 County: Huntington
Telephone: 814 542-8621
Products: Fiberglass underground storage tanks

Company: PPG Industries
Address: Works #27
City: Tipton State: PA Zip: 16684 County: Blair
Telephone: 814 684-2300
Products: Glass fabrications - automotive

Company: Brown Grp Recreation Products
Address: Sunny Rd. PO box 432
City: Bedford State: PA Zip: 15522 County: Bedford
Telephone: 814 623-9041
Products: Outdoor sports equipment

Company: Fonda Container
Address: PO Box E
City: Williamsburg State: PA Zip: 16693 County: Blair
Telephone: 814 832-3491
Products: Plastic and paper cups and plates

Company: Jomar Plastics
Address: Lloyd Street Ln.
City: Nanty Glo State: PA Zip: 15943 County: Cambria
Telephone: 814 749-9131
Products: Plastic bags

Company: Cresson Plastics Inc.
Address: 1027 Front St.
City: Cresson State: PA Zip: 16630 County: Cambria
Telephone: 814 886-7193
Products: Plastic caps, plugs, closures, protectors

Company: Lithcote Co.
Address: 6th & Chestnut Ave. PO Box 2003
City: Altoona State: PA Zip: 16603 County: Blair
Telephone: 814 944-4523
Products: Plastic coated tanks

Company: Laurel Plastics Inc.
Address: RD4 Box 267
City: Somerset State: PA Zip: 15501 County: Somerset
Telephone: 814 443-3422
Products: Plastic custom injection moldings

Company: H & M Dental Labs
Address: 533 Horner St. PO Box 504
City: Johnstown State: PA Zip: 15907 County: Cambria
Telephone: 814 536-2626

Products: Plastic dental prosthetics

3

Company: Endres Wood-Plastics Inc
Address: Fairgrounds Rd. PO Box 396
City: Huntington State: PA Zip: 16652 County: Huntington
Telephone: 814 643-1860
Products: Plastic doors, trim

ompany: C-cor Elex Inc.
ddress: 208 E Howard Ave.
City: Altoona State: PA Zip: 16601 County: Blair
Telephone: 814 944-3504
Products: Plastic electric cable

Company: Elco Corp. / Connector Division
Address: Huntington Industrial Park
City: Huntington State: PA Zip: 16652 County: Huntington
Telephone: 814 643-0700
Products: Plastic electronic molded parts

Company: Waring Products
Address: 1 Crystal Dr.
City: McConnellsburg State: PA Zip: 17233 County: Fulton
Telephone: 717 485-4871
Products: Plastic ice cream makers and blenders

Company: Galliker Dairy Co.
Address: 143 McDonald Lane PO Box 159
City: Johnstown State: PA Zip: 15907 County: Cambria
Telephone: 814 266-8702
Products: Plastic jugs for their milk

ompany: Sanitary Dairy
ddress: 408 Franklin St.
City: Johnstown State: PA Zip: 15901 County: Cambria
Telephone: 814 536-7551
Products: Plastic jugs for their milk

Company: Modern Cabinet & Construction
Address: 110 Frankstown Ave.
City: Altoona State: PA Zip: 16602 County: Blair
Telephone: 814 942-1000
Products: Plastic laminated cabinets and countertops

Company: Gilmour Manufacturing Co.
Address: PO Box 838
City: Somerset State: PA Zip: 15501 County: Somerset
Telephone: 814 443-4802
Products: Plastic lawn and garden products

Company: Green Garden Inc.
Address: RD5 PO Box 351
City: Somerset State: PA Zip: 15501 County: Somerset
Telephone: 814 443-3611
Products: Plastic lawn and garden products

Company: May & Bigley Inc.
Address: Railroad St. PO Box 667
ity: Bedford State: PA Zip: 15522 County: Bedford
Telephone: 814 623-9414
Products: Plastic moldings for telephone equip.

Company: Penn Mold & Tool Inc.
Address: RD2 Box 606
City: Altoona State: PA Zip: 16601 County: Blair
Telephone: 814 695-9294

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Products: Plastic molds for injection moldings

4

Company: Blair Tool & Plastic Inc.
Address: PO Box 124
City: East Freedom State: PA Zip: 16637 County: Blair
Telephone: 814 695-2032
Products: Plastic molds and dies

Company: K & H Die & Mold Co.
Address: RD3
City: Somerset State: PA Zip: 15501 County: Somerset
Telephone: 814 445-9584
Products: Plastic molds

Company: Superlative Pole Inc.
Address: 233 North St.
City: Bedford State: PA Zip: 15522 County: Bedford
Telephone: 814 623-8117
Products: Plastic products

Company: Cliant Inc.
Address: 800 2nd St.
City: Cresson State: PA Zip: 16630 County: Cambria
Telephone: 814 886-8171
Products: Plastic products and toys

Company: Molded Composites Inc.
Address: 102 Market Square PO Box 191
City: Meyersdale State: PA Zip: 15552 County: Somerset
Telephone: 814 634-8932
Products: Plastic reinforced parts

Company: Proctor-Silex Inc.
Address: U.S. Route 220 N PO Box 352
City: Altoona State: PA Zip: 16603 County: Blair
Telephone: 814 944-5371
Products: Plastic small appliances

Company: James Industies Inc.
Address: Beaver St. Ext. PO Box 230
City: Hollidaysburg State: PA Zip: 16648 County: Blair
Telephone: 814 695-5681
Products: Plastic toys

Company: Westinghouse Electric Corp.
Address: PO Box 657
City: Bedford State: PA Zip: 15522 County: Bedford
Telephone: 814 623-9014
Products: Plastic wire insulation

Company: Shields Rubber Corp
Address: Route 22 W Pensacola Rd. PO Box 113
City: Ebensburg State: PA Zip: 15931 County: Cambria
Telephone: 814 472-5224
Products: Rubber hoses and fittings

Company: Kennametal Inc.
Address: RD1 PO Box 161
City: Bedford State: PA Zip: 15522 County: Bedford
Telephone: 814 623-2711
Products: Tungsten carbide mining tools

Organized by Co. Name.

Address: PO Drawer 179
City: Mount Union State: PA Zip: 17066 County: Huntington
Telephone: 814 542-2551
Products: Ceramic non-clay refractories

Company: Bedford Reinforced Plastics
Address: RD2 Box 412
City: Bedford State: PA Zip: 15522 County: Bedford
Telephone: 814 623-9041
Products: Fiberglass products

Company: Blair Clay Products
Address: S 10th Ave. & 34th St. PO Box 872
City: Altoona State: PA Zip: 16603 County: Blair
Telephone: 814 943-6132
Products: Ceramic fire ladle brick

Company: Blair Tool & Plastic Inc.
Address: PO Box 124
City: East Freedom State: PA Zip: 16637 County: Blair
Telephone: 814 695-2032
Products: Plastic molds and dies

Company: Brown Grp Recreation Products
Address: Sunny Rd. PO box 432
City: Bedford State: PA Zip: 15522 County: Bedford
Telephone: 814 623-9041
Products: Outdoor sports equipment

Company: C-cor Elex Inc.
Address: 208 E Howard Ave.
City: Altoona State: PA Zip: 16601 County: Blair
Telephone: 814 944-3504
Products: Plastic electric cable

Company: Cannondale Corp.
Address: RD6 Friendship Rd. PO Box 500
City: Bedford State: PA Zip: 15522 County: Bedford
Telephone: 814 623-9073
Products: Aluminum bicycles

Company: Cliant Inc.
Address: 800 2nd St.
City: Cresson State: PA Zip: 16630 County: Cambria
Telephone: 814 886-8171
Products: Plastic products and toys

Company: Creative Pultrusions Inc.
Address: Pleasantville Industrial Park
City: Alum Bank State: PA Zip: 15521 County: Bedford
Telephone: 814 839-4186
Products: Fiberglass products

Company: Cresson Plastics Inc.
Address: 1027 Front St.
City: Cresson State: PA Zip: 16630 County: Cambria
Telephone: 814 886-7193
Products: Plastic caps, plugs, closures, protectors

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Company: Elco Corp. / Connector Division
Address: Huntington Industrial Park
City: Huntington State: PA Zip: 16652 County: Huntington
Telephone: 814 643-0700
Products: Plastic electronic molded parts

Address: Fairgrounds Rd. PO Box 396
City: Huntington State: PA Zip: 16652 County: Huntington
Telephone: 814 643-1860
Products: Plastic doors, trim

Company: F R P Fabrication
Address: Box 388
City: Huntington State: PA Zip: 16652 County: Huntington
Telephone: 814 643-2525
Products: Fiberglass and nonmetallic mineral products

Company: Fonda Container
Address: PO Box E
City: Williamsburg State: PA Zip: 16693 County: Blair
Telephone: 814 832-3491
Products: Plastic and paper cups and plates

Company: Fry Metal Inc.
Address: 6th Ave. & 41st St.
City: Altoona State: PA Zip: 16602 County: Blair
Telephone: 814 946-1611
Products: Extruded metals, and lead products

Company: Galliker Dairy Co.
Address: 143 McDonald Lane PO Box 159
City: Johnstown State: PA Zip: 15907 County: Cambria
Telephone: 814 266-8702
Products: Plastic jugs for their milk

Company: General Refractories
Address: Bedford St.
City: Claysburg State: PA Zip: 16625 County: Blair
Telephone: 814 239-2121
Products: Ceramic coke oven brick

Company: Gilmour Manufacturing Co.
Address: PO Box 838
City: Somerset State: PA Zip: 15501 County: Somerset
Telephone: 814 443-4802
Products: Plastic lawn and garden products

Company: Green Garden Inc.
Address: RD5 PO Box 351
City: Somerset State: PA Zip: 15501 County: Somerset
Telephone: 814 443-3611
Products: Plastic lawn and garden products

Company: H & M Dental Labs
Address: 533 Horner St. PO Box 504
City: Johnstown State: PA Zip: 15907 County: Cambria
Telephone: 814 536-2626
Products: Plastic dental prosthetics

Company: Industrial Refractories Inc.
Address: 101 Swank Ct.
City: Johnstown State: PA Zip: 15901 County: Cambria
Telephone: 814 535-5592
Products: Ceramic refractory, nozzles, sleeves, brick

Company: James Industies Inc.
Address: Beaver St. Ext. PO Box 230
City: Hollidaysburg State: PA Zip: 16648 County: Blair
Telephone: 814 695-5681
Products: Plastic toys

Address: Lloyd Street Ln.
City: Nanty Glo State: PA Zip: 15943 County: Cambria
Telephone: 814 749-9131
Products: Plastic bags

Company: K & H Die & Mold Co.
Address: RD3
City: Somerset State: PA Zip: 15501 County: Somerset
Telephone: 814 445-9584
Products: Plastic molds

Company: Kennametal Inc.
Address: RD1 PO Box 161
City: Bedford State: PA Zip: 15522 County: Bedford
Telephone: 814 623-2711
Products: Tungsten carbide mining tools

Company: Laurel Plastics Inc.
Address: RD4 Box 267
City: Somerset State: PA Zip: 15501 County: Somerset
Telephone: 814 443-3422
Products: Plastic custom injection moldings

Company: Lithcote Co.
Address: 6th & Chestnut Ave. PO Box 2003
City: Altoona State: PA Zip: 16603 County: Blair
Telephone: 814 944-4523
Products: Plastic coated tanks

Company: Maryland Refractories Co.
Address: PO Box 355
City: Alexandria State: PA Zip: 16611 County: Huntington
Telephone: 814 669-4452
Products: Ceramic clay refractories

Company: May & Bigley Inc.
Address: Railroad St. PO Box 667
City: Bedford State: PA Zip: 15522 County: Bedford
Telephone: 814 623-9414
Products: Plastic moldings for telephone equip.

Company: Modern Cabinet & Construction
Address: 110 Frankstown Ave.
City: Altoona State: PA Zip: 16602 County: Blair
Telephone: 814 942-1000
Products: Plastic laminated cabinets and countertops

Company: Molded Composites Inc.
Address: 102 Market Square PO Box 191
City: Meyersdale State: PA Zip: 15552 County: Somerset
Telephone: 814 634-8932
Products: Plastic reinforced parts

Company: Owens-Corning Fiberglass Corp.
Address: 12th & Susquehanna Ave. PO Box 382
City: Huntington State: PA Zip: 16652 County: Huntington
Telephone: 814 643-3240
Products: Fiberglass and glass yarns, fiberglass tanks

Company: Owens-Corning Fiberglas Corp.
Address: RD1 PO Box 299
City: Mount Union State: PA Zip: 17066 County: Huntington
Telephone: 814 542-8621
Products: Fiberglass underground storage tanks

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Address: RD2 Box 606
City: Altoona State: PA Zip: 16601 County: Blair
Telephone: 814 695-9294
Products: Plastic molds for injection moldings

Company: PPG Industries
Address: Works #27
City: Tipton State: PA Zip: 16684 County: Blair
Telephone: 814 684-2300
Products: Glass fabrications - automotive

Company: Proctor-Silex Inc.
Address: U.S. Route 220 N PO Box 352
City: Altoona State: PA Zip: 16603 County: Blair
Telephone: 814 944-5371
Products: Plastic small appliances

Company: Reihart, N. E. & Sons
Address: 821 Juniata Ave.
City: Huntington State: PA Zip: 16652 County: Huntington
Telephone: 814 643-0541
Products: Fiberglass tank parts

Company: Sanitary Dairy
Address: 408 Franklin St.
City: Johnstown State: PA Zip: 15901 County: Cambria
Telephone: 814 536-7551
Products: Plastic jugs for their milk

Company: Shields Rubber Corp
Address: Route 22 W Pensacola Rd. PO Box 113
City: Ebensburg State: PA Zip: 15931 County: Cambria
Telephone: 814 472-5224
Products: Rubber hoses and fittings

Company: Superlative Pole Inc.
Address: 233 North St.
City: Bedford State: PA Zip: 15522 County: Bedford
Telephone: 814 623-8117
Products: Plastic products

Company: U S Sports
Address: Industrial Park
City: Huntington State: PA Zip: 16652 County: Huntington
Telephone: 814 643-2222
Products: Canvas and rubber footwear

Company: Waring Products
Address: 1 Crystal Dr.
City: McConnellsburg State: PA Zip: 17233 County: Fulton
Telephone: 717 485-4871
Products: Plastic ice cream makers and blenders

Company: Westinghouse Electric Corp.
Address: PO Box 657
City: Bedford State: PA Zip: 15522 County: Bedford
Telephone: 814 623-9014
Products: Plastic wire insulation

Organized by Product.

Company: Cannondale Corp.
Address: RD6 Friendship Rd. PO Box 500
City: Bedford State: PA Zip: 15522 County: Bedford
Telephone: 814 623-9073
Products: Aluminum bicycles

Company: U S Sports
Address: Industrial Park
City: Huntington State: PA Zip: 16652 County: Huntington
Telephone: 814 643-2222
Products: Canvas and rubber footwear

Company: Maryland Refractories Co.
Address: PO Box 355
City: Alexandria State: PA Zip: 16611 County: Huntington
Telephone: 814 669-4452
Products: Ceramic clay refractories

Company: General Refractories
Address: Bedford St.
City: Claysburg State: PA Zip: 16625 County: Blair
Telephone: 814 239-2121
Products: Ceramic coke oven brick

Company: Blair Clay Products
Address: S 10th Ave. & 34th St. PO Box 872
City: Altoona State: PA Zip: 16603 County: Blair
Telephone: 814 943-6132
Products: Ceramic fire ladle brick

Company: Allied Corp.
Address: PO Drawer 179
City: Mount Union State: PA Zip: 17066 County: Huntington
Telephone: 814 542-2551
Products: Ceramic non-clay refractories

Company: Industrial Refractories Inc.
Address: 101 Swank Ct.
City: Johnstown State: PA Zip: 15901 County: Cambria
Telephone: 814 535-5592
Products: Ceramic refractory, nozzles, sleeves, brick

Company: Fry Metal Inc.
Address: 6th Ave. & 41st St.
City: Altoona State: PA Zip: 16602 County: Blair
Telephone: 814 946-1611
Products: Extruded metals, and lead products

Company: Creative Pultrusions Inc.
Address: Pleasantville Industrial Park
City: Alum Bank State: PA Zip: 15521 County: Bedford
Telephone: 814 839-4186
Products: Fiberglass products

Company: Bedford Reinforced Plastics
Address: RD2 Box 412
City: Bedford State: PA Zip: 15522 County: Bedford
Telephone: 814 623-9041
Products: Fiberglass products

Company: F R P Fabrication
Address: Box 388
City: Huntington State: PA Zip: 16652 County: Huntington
Telephone: 814 643-2525
Products: Fiberglass and nonmetallic mineral products

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ddress: 12th & Susquehanna Ave. PO Box 382
ity: Huntington State: PA Zip: 16652 County: Huntington
elephone: 814 643-3240
roducts: Fiberglass and glass yarns, fiberglass tanks

ompany: Reihart, N. E. & Sons
ddress: 821 Juniata Ave.
C[illegible] Huntington State: PA Zip: 16652 County: Huntington
[illegible]hone: 814 643-0541
roducts: Fiberglass tank parts

ompany: Owens-Corning Fiberglas Corp.
Address: RD1 PO Box 299
City: Mount Union State: PA Zip: 17066 County: Huntington
Telephone: 814 542-8621
Products: Fiberglass underground storage tanks

Company: PPG Industries
Address: Works #27
City: Tipton State: PA Zip: 16684 County: Blair
Telephone: 814 684-2300
Products: Glass fabrications - automotive

Company: Brown Grp Recreation Products
Address: Sunny Rd. PO box 432
City: Bedford State: PA Zip: 15522 County: Bedford
Telephone: 814 623-9041
Products: Outdoor sports equipment

Company: Fonda Container
Address: PO Box E
Ci[illegible] Williamsburg State: PA Zip: 16693 County: Blair
Te[illegible]hone: 814 832-3491
Products: Plastic and paper cups and plates

Company: Jomar Plastics
Address: Lloyd Street Ln.
City: Nanty Glo State: PA Zip: 15943 County: Cambria
Telephone: 814 749-9131
Products: Plastic bags

Company: Cresson Plastics Inc.
Address: 1027 Front St.
City: Cresson State: PA Zip: 16630 County: Cambria
Telephone: 814 886-7193
Products: Plastic caps, plugs, closures, protectors

Company: Lithcote Co.
Address: 6th & Chestnut Ave. PO Box 2003
City: Altoona State: PA Zip: 16603 County: Blair
Telephone: 814 944-4523
Products: Plastic coated tanks

Company: Laurel Plastics Inc.
Address: RD4 Box 267
City: Somerset State: PA Zip: 15501 County: Somerset
Te[illegible]hone: 814 443-3422
Pr[illegible]ts: Plastic custom injection moldings

Company: H & M Dental Labs
Address: 533 Horner St. PO Box 504
City: Johnstown State: PA Zip: 15907 County: Cambria
Telephone: 814 536-2626
Products: Plastic dental prosthetics

Company: Endres Wood-Plastics Inc
Address: Fairgrounds Rd. PO Box 396
City: Huntington State: PA Zip: 16652 County: Huntington
Telephone: 814 643-1860
Products: Plastic doors, trim

Company: C-cor Elex Inc.
Address: 208 E Howard Ave.
C[illegible] Altoona State: PA Zip: 16601 County: Blair
T[illegible]phone: 814 944-3504
Products: Plastic electric cable

Company: Elco Corp. / Connector Division
Address: Huntington Industrial Park
City: Huntington State: PA Zip: 16652 County: Huntington
Telephone: 814 643-0700
Products: Plastic electronic molded parts

Company: Waring Products
Address: 1 Crystal Dr.
City: McConnellsburg State: PA Zip: 17233 County: Fulton
Telephone: 717 485-4871
Products: Plastic ice cream makers and blenders

Company: Galliker Dairy Co.
Address: 143 McDonald Lane PO Box 159
City: Johnstown State: PA Zip: 15907 County: Cambria
Telephone: 814 266-8702
Products: Plastic jugs for their milk

Company: Sanitary Dairy
Ad[illegible]ss: 408 Franklin St.
C[illegible] Johnstown State: PA Zip: 15901 County: Cambria
Te[illegible]phone: 814 536-7551
Products: Plastic jugs for their milk

Company: Modern Cabinet & Construction
Address: 110 Frankstown Ave.
City: Altoona State: PA Zip: 16602 County: Blair
Telephone: 814 942-1000
Products: Plastic laminated cabinets and countertops

Company: Gilmour Manufacturing Co.
Address: PO Box 838
City: Somerset State: PA Zip: 15501 County: Somerset
Telephone: 814 443-4802
Products: Plastic lawn and garden products

Company: Green Garden Inc.
Address: RD5 PO Box 351
City: Somerset State: PA Zip: 15501 County: Somerset
Telephone: 814 443-3611
Products: Plastic lawn and garden products

Company: May & Bigley Inc.
Address: Railroad St. PO Box 667
City: Bedford State: PA Zip: 15522 County: Bedford
T[illegible]hone: 814 623-9414
P[illegible]cts: Plastic moldings for telephone equip.

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Company: Penn Mold & Tool Inc.
Address: RD2 Box 606
City: Altoona State: PA Zip: 16601 County: Blair

Company: Blair Tool & Plastic Inc.
Address: PO Box 124
City: East Freedom State: PA Zip: 16637 County: Blair
Telephone: 814 695-2032
Products: Plastic molds and dies

Company: K & H Die & Mold Co.
Address: RD3
[illegible]: Somerset State: PA Zip: 15501 County: Somerset
Telephone: 814 445-9584
Products: Plastic molds

Company: Superlative Pole Inc.
Address: 233 North St.
City: Bedford State: PA Zip: 15522 County: Bedford
Telephone: 814 623-8117
Products: Plastic products

Company: Cliant Inc.
Address: 800 2nd St.
City: Cresson State: PA Zip: 16630 County: Cambria
Telephone: 814 886-8171
Products: Plastic products and toys

Company: Molded Composites Inc.
Address: 102 Market Square PO Box 191
City: Meyersdale State: PA Zip: 15552 County: Somerset
Telephone: 814 634-8932
Products: Plastic reinforced parts

Company: Proctor-Silex Inc.
Address: U.S. Route 220 N PO Box 352
[illegible]: Altoona State: PA Zip: 16603 County: Blair
Telephone: 814 944-5371
Products: Plastic small appliances

Company: James Industies Inc.
Address: Beaver St. Ext. PO Box 230
City: Hollidaysburg State: PA Zip: 16648 County: Blair
Telephone: 814 695-5681
Products: Plastic toys

Company: Westinghouse Electric Corp.
Address: PO Box 657
City: Bedford State: PA Zip: 15522 County: Bedford
Telephone: 814 623-9014
Products: Plastic wire insulation

Company: Shields Rubber Corp
Address: Route 22 W Pensacola Rd. PO Box 113
City: Ebensburg State: PA Zip: 15931 County: Cambria
Telephone: 814 472-5224
Products: Rubber hoses and fittings

Company: Kennametal Inc.
Address: RD1 PO Box 161
City: Bedford State: PA Zip: 15522 County: Bedford
Telephone: 814 623-2711
Products: Tungsten carbide mining tools

Organized by county. (Abbreviated data)

```
Company: Creative Pultrusions Inc.  County: Bedford
Company: Bedford Reinforced Plastics  County: Bedford
Company: Brown Grp Recreation Products  County: Bedford
Company: Cannondale Corp.  County: Bedford
Company: Kennametal Inc.  County: Bedford
Company: May & Bigley Inc.  County: Bedford
Company: Superlative Pole Inc.  County: Bedford
Company: Westinghouse Electric Corp.  County: Bedford
Company: Blair Clay Products  County: Blair
Company: C-cor Elex Inc.  County: Blair
Company: Fry Metal Inc.  County: Blair
Company: Lithcote Co.  County: Blair
Company: Modern Cabinet & Construction  County: Blair
Company: Penn Mold & Tool Inc.  County: Blair
Company: Proctor-Silex Inc.  County: Blair
Company: General Refractories  County: Blair
Company: Blair Tool & Plastic Inc.  County: Blair
Company: James Industies Inc.  County: Blair
Company: PPG Industries  County: Blair
Company: Fonda Container  County: Blair
Company: Cliant Inc.  County: Cambria
Company: Cresson Plastics Inc.  County: Cambria
Company: Shields Rubber Corp  County: Cambria
Company: Galliker Dairy Co.  County: Cambria
Company: H & M Dental Labs  County: Cambria
Company: Industrial Refractories Inc.  County: Cambria
Company: Sanitary Dairy  County: Cambria
Company: Jomar Plastics  County: Cambria
Company: Waring Products  County: Fulton
Company: Maryland Refractories Co.  County: Huntington
Company: Elco Corp. / Connector Division  County: Huntington
Company: Endres Wood-Plastics Inc  County: Huntington
Company: F R P Fabrication  County: Huntington
Company: Owens-Corning Fiberglass Corp.  County: Huntington
Company: Reihart, N. E. & Sons  County: Huntington
Company: U S Sports  County: Huntington
Company: Allied Corp.  County: Huntington
Company: Owens-Corning Fiberglas Corp.  County: Huntington
Company: Molded Composites Inc.  County: Somerset
Company: Gilmour Manufacturing Co.  County: Somerset
Company: Green Garden Inc.  County: Somerset
Company: K & H Die & Mold Co.  County: Somerset
Company: Laurel Plastics Inc.  County: Somerset
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SECTION VI - PROPOSED ARTICULATION AGREEMENT

ARTICULATION PROGRAM
Between the
ENGINEERING TECHNOLOGY DIVISION
of the University of Pittsburgh at Johnstown
and the
BEDFORD-EVERETT AREA VOCATIONAL-TECHNICAL SCHOOL

OBJECTIVE:

The University of Pittsburgh at Johnstown's Engineering Technology Division and the Bedford-Everret Area Vocational-Technical School agree to the establish an articulatory program. This program's purpose is to give graduates of the Metal Technology and Advanced Material Technology curriculum at BEAVTS who have chosen to further their education in the area of engineering technology an opportunity to earn up to 14 college credits toward a B.S. degree in Engineering Technology.

PARTICIPATION PROCEDURE:

Students desiring to participate in the program should be advised of the required high school courses and any other recommended electives prior to their sophomore year. Students will be required to apply for admission into the Engineering Technology Program, and, upon admission, request for and pass competency exams in the appropriate courses to earn these college credits. It is recognized that students may need additional intense study before taking the competency exams. By passing the competency exams, students will be able to reduce the cost of their college education by reducing their total credits by up to 14 credits or they may choose to take additional electives in their major to broaden or deepen their expertise. Tuition savings for 14 credits at the current tuition rate of $144 per credit would be $2016.

Admission criteria for the Engineering Technology Program at UPJ:

For admission into the Engineering Technology program at UPJ, the student must have credit for the following 15 secondary school academic units:

English - 4 units
Algebra - 2 units
Plane Geometry - 1 unit
Trigonometry - 1/2 unit
History - 1 unit
Chemistry - 1 unit
Physics - 1 unit
Academic Elective - 4 1/2 units

It is preferable to also have 1/2 unit of solid geometry and 1 year of higher mathematics.

Students are also required to have completed the Scholastic Aptitude Test (SAT) of the College Entrance Examination Board or the American College Test (ACT) battery in its entirety.

Each applicant is accorded individual consideration through a comprehensive evaluation of the following:

His or her previous school record.
The recommendation of his or her principal or guidance counselor.
His or her SAT score.
The student's aptitude and motivation for the predicted success in the specific program of his or her choice.

A composite evaluation is made by the Committee on Admissions and the applicant is notified by mail, usually within a month after all proper credentials have been received. All inquiries should be made to the Director of Admissions at UPJ.

Competency Exams:

Competency exams for earned credits are available for the following courses:

4 credits for Math 31 - Algebra and trigonometry
4 credits for ET 11 - Engineering drawing
3 credits for ET 30 - Computer programming
3 credits for MET 161 - Manufacturing processes

Students may elect to take any or all of the exams for the above courses, and competency will be evaluated for each exam. A passing grade will be awarded for each course in which the student scores a "C" or better on the appropriate exam. Students scoring below a "C" will not be awarded credit for that particular course.

To aid the student in study and preparation for the competency exams, brief course descriptions and the general topics covered in the above courses are attached for reference. Any future changes made in the curriculum that affect these courses, and therefore this articulation program will be forwarded to the BEAVTS.

GENERAL COURSE DESCRIPTIONS:

Math 31 - The application of algebraic, trigonometric, exponential, and logarithmic functions to the solution of typical mechanical, electrical, and civil engineering problems. Prerequisites for this course are one year of high school algebra, and one year of geometry.

ET 11 - The basics of engineering drawing are covered, including the use of instruments, lettering, and geometric constructions. The principles of orthographic projection used in both mechanical drawing and freehand sketches are the fundamentals of the course. Theory of dimensioning, sectional and auxiliary views, and assembly drawings add to the understanding of multiview concepts used in shop drawings. Approximately one fourth of the course is devoted to microcomputer based 2D and 3D CAD (Computer Aided Drafting) which utilizes CADKEY software.

ET 30 - This course introduces the student to the basic structure of a digital computer and several of its programming languages. Use of the FORTRAN language as a problem-solving tool is emphasized. The student is exposed to a wide variety of computer applications within the engineering field. Typical application areas include numerical methods, modeling, simulation, computer graphics, linear programming, statistical analysis, and engineering economics.

MET 161 - An overview of a variety of manufacturing processes that are available to process materials into finished products. Special emphasis is placed on the "traditional" processes from the standpoint of production methods, sequence of operations, and economic decision analysis. The impact of Computer Aided Manufacturing (CAM) in terms of its relationship to Computer Aided Design (CAD) utilizing numerically controlled equipment to perform these processes, and the integration of automation into manufacturing processes is introduced.

Note: Current course outlines are available from UPJ.

General topics covered in the above courses follow:

Math 31:
Fundamental laws of algebra and order of operations.
Exponents, roots and radicals, and scientific notation.
Functions and graphs.
Systems of linear equations, and determinants.
Factoring and fractions (special products, trinomials, operations with fractions).
Quadratic equations (factoring, solving and graphing)
Trigonometric functions (definitions, use, manipulation, and graphing).

ET 11:
Proper mechanical drawing equipment nomenclature.
Proper mechanical drawing equipment usage.
Geometric construction principles and techniques.
Use and terminology of various line types.
Free hand sketching techniques.
Multiview projection principles.
Position and placement of the six standard views.
Necessary views to define shapes of objects.
Hierarchy of lines.
Size description - dimensioning technique, selection, placement, and practices.
Shop processes.
Drawing scales.
Section views - types, techniques, and practices.
Auxiliary views - construction, use, types, practices.
Assembly drawings.
2D and 3D CAD principles, and application.

ET 30:
Structure of computers.
Developing algorithms.
Flow charting and pseudo codes.
Program content and commands.
Program design, testing and debugging.
Control structure (selection, repetition, and sequential operations).
Vectors and arrays.
Searching and sorting techniques.
Subprograms.
File handling and data structures.
* FORTRAN language used for this course.

MET 161:
Primary casting processes and characteristics.
Casting design considerations.
Powder metallurgy (P/M) process.
P/M properties and design considerations.
Metal working processes - Hot and Cold working
  Rolling, forging, extrusion, drawing, spinning, etc.
Measurement and inspection instruments and practices.
Machining processes and applications - shaping, planing, turning and boring, drilling, milling, abrasive machining, broaching, sawing, filing, etc.
Welding processes - Forge, arc, resistance, etc.
Manufacturing systems, numerical control, and automation.

Thursday, April 14, 1988 — Bedford Gazette, Bedford, P

Vo-Tech 85% is above averag

[illegible]ETT — The Bedford-E[illegible] Area Vocational-Technical Sch[illegible]s operating at about 85 percent capacity, director Barry Dallara told members of the joint operating committee Tuesday.

Moreover, Dallara said he expects the AVTS to continue attracting those numbers in the future.

Dallara was responding to the 18th annual report of the Pennsylvania Council on Vocational Education. The council has found vocational education needs new direction in order to survive.

Using the building construction class as an example, Dallara explained the "cluster" concept of vocational education.

Underclassmen receive a broad spectrum of instruction in a given area. The students begin to specialize in their senior year. A post-secondary and adult training program provides another degree of specialization. "If we're serious about Vocational Education, then that's the direction we have to go," D[illegible] said.

[illegible]cal AVTS has already headed down that path by offering adult retraining programs and other post-secondary opportunities. Dallara would like to see the AVTS gain institute status, and he asked the committee to endorse a letter to state Sen. Robert Jubelirer, stressing the importance of post-secondary vocational education and asking his support for measures outlined in the council's report. The committee posted the letter Tuesday night.

To further the creditability of the AVTS, Dallara is instituting the Pennsylvania Skills Test for seniors. Seniors who successfully pass the test will be awarded a Pennsylvania Skills Certificate that will help students find jobs in their chosen field.

Kerry Barefoot, who teaches Building Trades at the AVTS, helped develop the national test in that field.

Testing at the AVTS will begin later this month with both written and hands-on testing. "These are difficult tests," Dallara assured the committee. "Not all students will be able to pass them."

The tests are administered by outside advisors and monitored by someone other than the course's teacher. "We're very concerned about valid scores," Dallara said.

The results are sent to the National Occupational Competency Testing Institute for evaluation. Individual scores determine eligibility for Pennsylvania certification.

The AVTS will be testing in five of the seven course offerings. Cosmetology has state boards which set the competency standards and the Health Services course has just begun a three-year program.

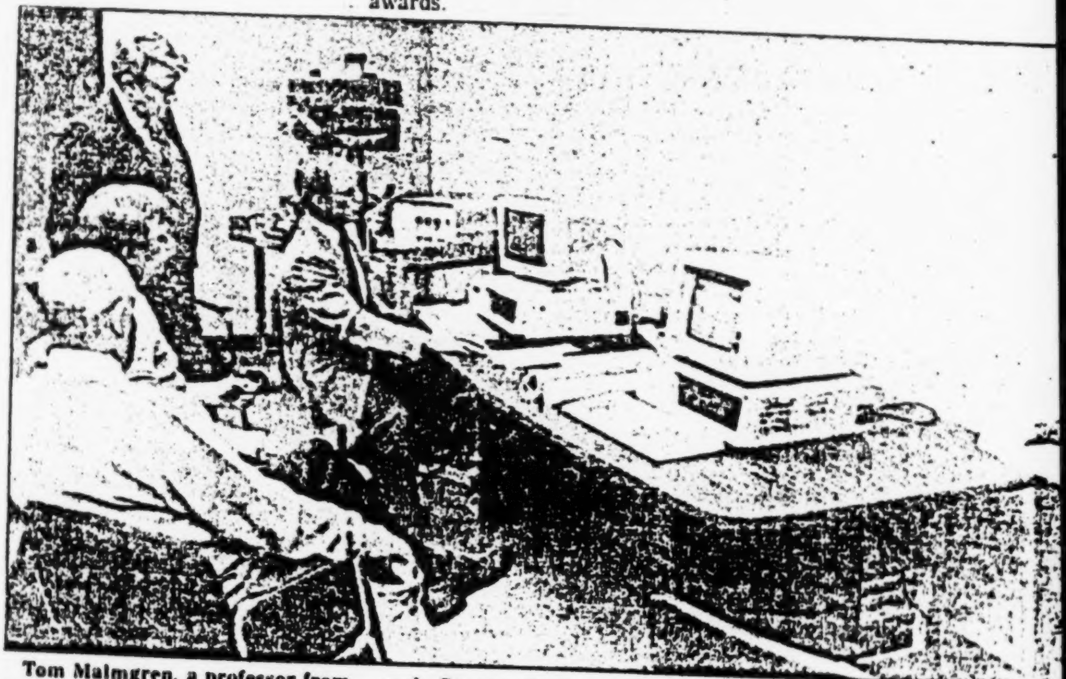
The board witnessed a CAD/CAM demonstration Tuesday by University of Pittsburgh professor Tom Malmgren and Metal Fabrications instructor Steve Orner. The demonstration was scheduled for a half hour before the committee was to meet, but was extended when the panel was late in convening.

—Approved Dallara and the two Data Processing instructors to attend a workshop in Altoona and approved Brenda Ault to take 35 students to Allegany Community College.

—Authorized the administration to advertise for bids on educational equipment and materials for the coming year.

—Approved Joe Fleck to teach 21 hours of Auto Inspection.

—Approved the administration applying for federal funds in both allocated and competitive funds awards.



Tom Malmgren, a professor from the University of Pittsburgh at Johnstown, (seated in front of the computer) and Steve Orner, the metal fabrications instructor at the Bedford-Everett Area Vocational-Technical School, (standing, rear) demonstrate the CAD/CAM capabilities being taught at the local AVTS to joint operating committee and George Stout. Malmgren is working at the AVTS to develop new programs for the re-inforced fiberglass industry. The computers can do detailed printouts and operate sophisticated milling equipment.

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RECEIVED
JUN 20 1988
BEDFORD-EVERETT AREA
VO-TECH SCHOOL

June 13, 1988

Mr. Paul Leister
Bedford-Everett Area Vocational-Technical School
R.D. #1 Box 460
Everett, PA 15537

Dear Mr. Leister

It is very exciting to us that in a die-hard steel state like Pennsylvania, an advanced composites course has potential for state-wide distribution.

Therefore, we willingly give you permission to use any of our published information, including the "Design Guide," towards the preparation of your course.

I also have a reference library available of technical presentations and magazine articles you might find useful.

Sincerely yours

CREATIVE PULTRUSIONS, INC.

David J. Evans

David J. Evans
Technical Director

DJE/sf

CC: Bob Sweet

CREATIVE PULTRUSIONS, INC.
Pleasantville Industrial Park Alum Bank, PA 15521 814-839-4186
FAX: 814-839-4276

northern state

RECEIVED
JUN 20 1988
BEDFORD EVERETT AREA
VO-TECH SCHOOL

June 14, 1988

Paul Leister
Bedford - Everett Area Vocational - Technical School
R.D. 1, Box 460
Everett, PA 15537

Dear Mr. Leister:

You may utilize selected charts from my book Plastics: Theory and Application for use in development of curricular materials for your school.

I might suggest that Delmar Publishing is printing my new text with new information and updated charts. This text will have the same title but will not be available until January, 1989. You may also be interested in my text Composites: A Design Guide published by the Industrial Press with a 1987 copyright.

Best of luck with your endeavor and please feel free to contact me if you have any questions.

Sincerely yours,

Terry Richardson (NN)

Dr. Terry Richardson, Chair
Industrial Technologies

nen

Industrial Technologies
Northern State
Aberdeen, South Dakota 57401
605 622-2571

Mitsubishi duo

By DAN McCOSH

KONA, HAWAII

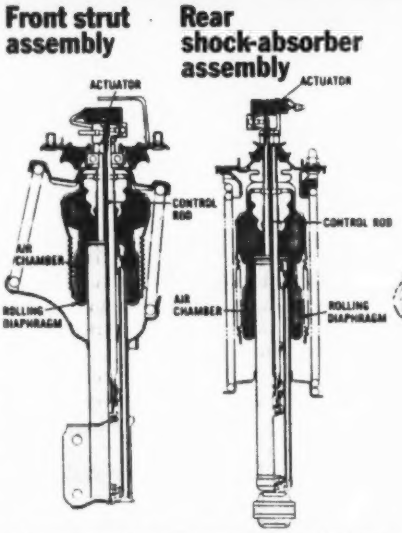
While driving Mitsubishi's new Galant on the winding cow paths that pass for roads in the center of the island of Hawaii, it took an unusually hard stab at the brakes or a tricky corner to provoke any sensation from the suspension.

I was expecting more of a show since both the spring rates and shock valving were constantly altering as the car's speed and cornering load changed; but the smooth ride was testimony to the refinement of what is likely the most sophisticated electronically controlled suspension system in a current production car. With this new suspension, three new engines, two new models (Galant and the smaller Mirage), a joint-venture plant with Chrysler Corp. starting up, and yet more new cars coming later in the year, Mitsubishi is making a serious effort at having an impact in the United States.

The basic hardware of the suspension system is composed of MacPherson struts up front, with a twisting-beam axle at the rear. The electronic twist comes with the active suspension package. Separate air springs are incorporated at the top of the struts, along with variable-rate shock valves. A set of seven sensors feeds information about vehicle speed, turning velocity, and braking to a central computer, which responds by sending out orders to pump up a sagging corner or tighten a hopping wheel. The response rate of the air system is about one-tenth of a second, quick but not instantaneous.

The Galant is also the showplace for a new two-liter 16-valve four-cylinder engine (see cutaway). The 16-valve-engine theme continues in the turbocharged version of the Mirage, a 94-inch-wheelbase subcompact also sold by Dodge as the Colt. The 1.6-liter turbo engine produces 135 horsepower. In its base form the Mirage engine develops 81 hp out of 1.5 liters.

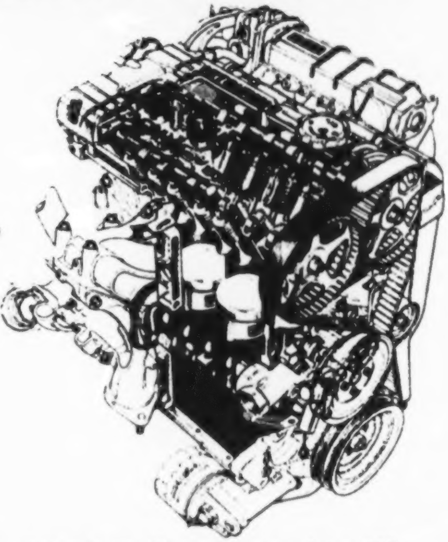
Like the Galant, the Mirage adopts the twisting-beam rear suspension. The turbo package adds rear disc brakes and stiffer springs to accommodate the added horsepower.



Front strut assembly

Rear shock-absorber assembly

Air-suspension actuator, controlled by the on-board computer, raises and lowers pressure of air chamber, located inside coil spring, according to road and handling characteristics.



Galant's two-liter engine produces 135 hp at 6,000 rpm. Roller-cam follower in the four-valve dual-overhead-cam head reduces friction; shake is damped by counterrotating balance shafts.

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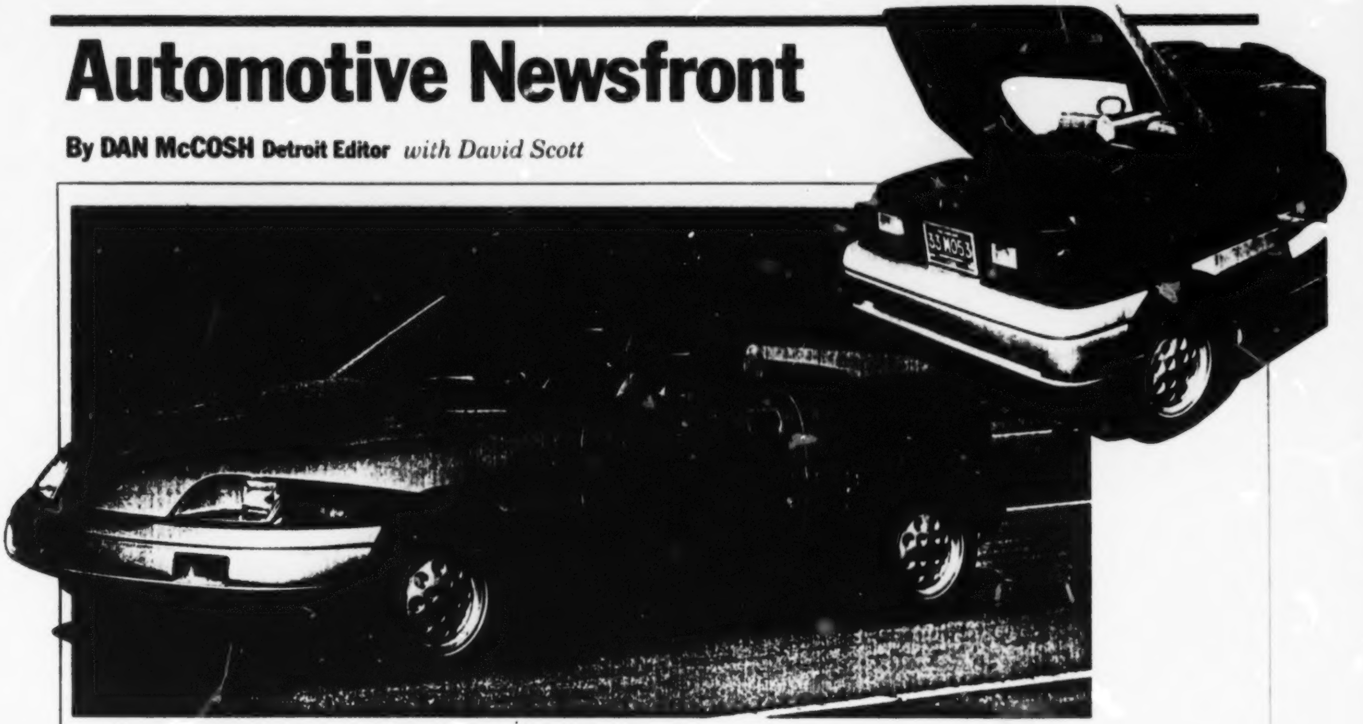
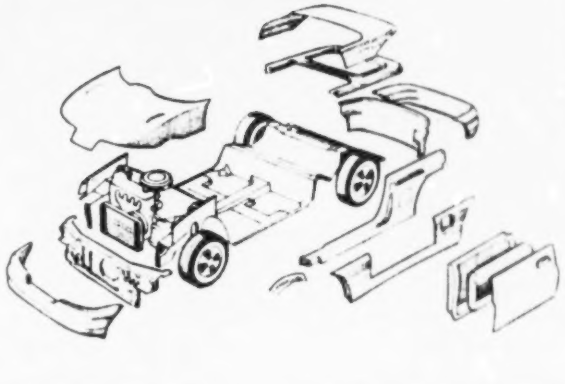
Automotive Newsfront

By DAN McCOSH Detroit Editor *with David Scott*



Ford's LIV is the latest attempt to use high-strength composites to manufacture an all-plastic car. Unlike most glass-fiber cars that use a metal chassis, the LIV molds the floorpan, suspension mounts, hood and other key elements from high-strength reinforced plastics. The exploded view (right) reveals how few basic pieces are needed to complete the car, compared with the hundreds of individually assembled parts in a conventionally constructed automobile.



Plastic sportster

Futuristic concept cars usually work better posing on a display turntable than they do when you actually try to *drive* them. That is why I was surprised by the solid "thunk" of the door as I got into Ford's latest advanced-concept "LIV" (for low-investment vehicle) at the company's Dearborn, Mich., proving ground recently.

A fast couple of laps around the handling track left me with the impression of a quick, able, well-balanced sports car combining the personality of an old MG with the grip of a modern performance car. Most of the LIV's underpinnings were taken from Ford of Europe's Fiesta GT, including its 1.6-liter engine and five-speed transmission—proven components that accounted for part of the solid feel.

But there's another big reason for my surprise: The car I drove was assembled from large-scale molded plastic sections at Ford's advanced research division. And, unlike the Corvette or the ill-fated Fiero, molded composite structures carry its major structural loads too. The result is a car that is built from one-fifth the number of pieces that are used in conventional construction.

Because plastic molds are some 60 percent cheaper than metal-stamping machinery, Ford hopes the process can dramatically reduce its production costs along with the retail price. The plastic structure also lent itself to some unusual design elements. A rear deck section incorporating the tops of the rear fenders lifts to reveal a trunk compartment that looks like a big Tupperware container.

To date, Ford has generally trailed behind both General Motors and Chrysler in the use of composite structures. But the LIV program shows that this may be changing as Ford studies the low-volume specialty car business, which lends itself to low-cost plastic production techniques.

Italian breadboxes

The so-called "one box" design dominated the show cars at this year's Turin auto show. An example was the Asgard, a six-passenger high-speed Audi-based limousine by Ital Design.

Even more weird was the Bertone Genesis, a vanlike five-passenger design exercise powered by a 500-horsepower V12 expected to give it performance comparable with the Lamborghini Countach.

Definitely the haute couture event in the world of body design, the Turin show often brings to light the furthest-out designs in the world. Looks like the breadbox look may be with us for a while.

Continued

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